EFFECT OF A MULTI-MODAL APPROACH ON DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

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ABSTRACT

Persistent poor performance in Mathematics among learners in rural Namibian schools, particularly in the Ncamagoro Circuit of the Kavango West Region, has been relatively attributed to the use of traditional teaching methods that fail to support number sense development. This study investigated the effects of a multimodal approach on the development of number sense in Grade 8 learners. It was guided by two research questions: *"1. What are the effects of a multimodal approach on the development of number sense in Grade 8 learners? 2. How does the multimodal approach affect Grade 8 learners' retention of numerical concepts?"* While previous studies in Namibia have examined number sense in the early phase, senior grades and among pre-service teachers, limited research has focused on junior secondary learners, particularly Grade 8, using experimental designs. The purpose of this study was to determine whether a multimodal approach, incorporating visual, auditory, and kinaesthetic modes, could offer a more effective alternative to traditional methods. A quasi-experimental design was used, involving a total population sample of 60 learners from two schools, with one group receiving multimodal instruction and the other taught using traditional approaches. To determine the learner's entry level of number sense before the intervention, a pre-test was given to both groups. A post-test that contained identical content as the pre-test was then administered to both groups again to measure the effects of the instructional approach after intervention. Quantitative data collected through pre-tests, post-tests, and follow-up assessments were analysed using t-tests and one-way repeated measures ANOVA. The experimental group performed better than the control group at every assessment point, according to the results, suggesting that the multimodal approach greatly enhanced both number sense development and long-term retention. This indicates that the multimodal approach effectively strengthened learners' understanding and retention of number concepts. The findings suggest that multimodal teaching has significant ability to improve Mathematics learning outcomes in under-resourced, rural educational settings such as that of the two schools in the Ncamagoro circuit, Kavango West Region.

Key words: arithmetic, multi-modal instruction, traditional approach, mean, standard deviation, descriptive statistics, auditory, visual, kinaesthetic and number sense.

DEDICATION

This thesis is dedicated to:

My mother: Tunga Maria Simuma

For her patience, prayers and time that I stole from her during my studies, I will always remember you for being my pillar of strength.

My Friend(s): Hamutenya Frans, Kavangu Ferstinus, Anton Johannes, Costa Benhard, Hamutenya Abel and Kambinda Joseph.

For their patient love, support, encouragement and prayers during the time that they rendered to me as I was carrying out this study. I will always remember you for being my pillar of strength and courage to move further when I felt like giving up. Thank you for giving my academic journey so much light and meaning.

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TABLE OF CONTENTS

CONTENTS **PAGE**

ACRONYMS/ABBREVIATIONS

- **UNAM**: University of Namibia
- **UREC**: University of Namibia Research Ethics Committee
- **ICF**: Informed Consent Form
- **SD**: Standard Deviation
- **M**: Mean
- **SPSS**: Statistical Package for the Social Sciences
- **ANOVA**: Analysis of Variance
- **t:** t-value
- **p:** p-value
- **F:** F-value
- **ED:** Executive Director
- **RD:** Regional Director
- **IOE:** Inspector of Education
- **LCE:** Learner Centred Education
- **ETSIP**: Education and Training Sector Improvement Programme in Namibia
- **MoEAC**: Ministry of Education, Arts and Culture

LIST OF FIGURES USED IN THIS STUDY

LIST OF TABLES USED IN THIS STUDY

DECLARATION

I Kahuli Moses hereby declare that "*The effects of a multi-modal approach on developing number sense in Grade 8 learners in Ncamagoro circuit, Kavango West Region*" is a true reflection of my research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher learning.

October 2025

Signature of student Date

CHAPTER 1: INTRODUCTION

1.1 Background of this study

In Namibia, Mathematics is a compulsory subject from Pre-primary to Grade 11 because of its significance and practical value in everyday applications; however, the majority of learners continue to perform poorly in Mathematics. Literature, as noted in Hamukwaya (2019) on Mathematics education, highlights numerous possible factors of poor performance, including learners' difficulties in learning and comprehending Mathematics. Research by Jatileni and Neshila (2023) as well as Abisai, Naukushu, and Kasanda (2019), the persistence of traditional, teacher-centred approaches in the teaching and learning of Mathematics impedes the development of important mathematical concepts like number sense and impairs learners' performance. There is need for more innovating approaches to the teaching of Mathematics that actively engage learners in mathematical inquiry and contribute to their development of High Order Thinking Skills (HOTS). This study focused on the use of one of such approaches, the multimodal instructional strategies in or order to determine how they may help develop number sense among Grade 8 learners in the Ncamagoro Circuit of the Kavango West Region. The context of this study is presented with an overview of Mathematics education in Namibia, particularly the persistent challenges in teaching number sense in rural secondary schools.

The development of number sense remains a persistent challenge in many Namibian classrooms, as reported in regions such as Oshana and Oluno Circuit (Chirimbana, Makaka, & Hilongwa, 2024; Naukushu, 2011), and is likely to be more evident in under-resourced rural areas like Ncamagoro Circuit in Kavango West Region. Number sense, which is the ability to understand numbers, their relationships, and operations, is a critical

component of mathematical proficiency. However, research has revealed that Namibian learners, regardless of their grade level, have a poor sense of numbers and how to operate in them. This weakness is characterized by their struggles with estimation, mental arithmetic, and basic numerical concepts (Naukushu, 2011; Potgieter, 2015; Ndinelago, 2021). For instance, Naukushu (2011) found that Grade 12 learners in the Oshana Region exhibited underdeveloped number sense, leading to consistently poor performance in national Mathematics examinations. Similarly, Potgieter (2015) found that the absence of manipulative-based instruction prevented Grade 2 learners from making the connection between abstract number concepts and tangible learning experiences, which may hinder their understanding of harder mathematical concepts later in higher grades.

In recent years, research has increasingly advocated for more creative and multimodal teaching strategies in particular that uses a variety of instructional modalities, including tactile, kinaesthetic, visual, and auditory, to improve learning outcomes and experiences; this helps to address the challenges highlighted above, as demonstrated in related literature. Although Ayimbila and Pappoe (2022) conducted their study within the subject of Biology, their findings are relevant to this study due to the effective use of multimodal strategies that improved learners' understanding and engagement. Similar to this, Maryam et al. (2011) showed that, despite their focus on science education, using a variety of representations to present content, including text, images, videos, and interactive tools, helped accommodate learners' varying learning styles and, in the end, improved concept retention and application. These observations can be applied to the teaching of Mathematics, where abstract ideas such as number sense necessitate deep connections made through a variety of cognitive and sensory experiences. Several studies in Namibia

support this; for example, Ndinelago (2021) explored the use of the abacus as a visual tool in Grade 3 and found it improved learners' comprehension of numerical relationships. Similarly, Kleopas, Chirimbana and Shuukwanyama (2023) demonstrated that diverse teaching methods enhance learner participation and problem-solving skills in rural settings.

Learners with poor number sense often struggle with basic arithmetic tasks such as estimation, ordering numbers, comparing integers, and performing operations with negative numbers. Boonen et al. (2014), in their study on visual spatial skills and visual representation strategies in mathematical word problem solving, demonstrated that learners benefit significantly from instructional approaches that engage multiple senses, particularly visual modalities. Although their focus was on problem solving, their findings support the value of multimodal teaching strategies in Mathematics. Similarly, Jacobson (2023), while exploring the cognitive impacts of multisensory learning environments in general education, argued that learners grasp concepts more effectively when content is presented using various sensory modalities. Their findings suggest that learners benefit significantly when instructional strategies incorporate multiple sensory modalities, such as visual aids, hands-on tools, and verbal explanations. Although these studies are not rooted in the Namibian Mathematics curriculum, their emphasis on multimodal engagement is highly relevant in contexts like the Ncamagoro circuit, where limited access to diverse teaching resources and heavy reliance on classroom instruction for conceptual development make it essential to adopt inclusive and interactive teaching strategies such as the multimodal approach that supports learners' number concept development.

This study aligns with the goals of Namibia's Education and Training Sector Improvement Programme (ETSIP), which advocates for learner-centred teaching and improved Mathematics outcomes through innovative instructional methods (Ministry of Education, 2007). By exploring a multimodal approach, this study supports ETSIP's aim to enhance learning quality and relevance, particularly in underperforming rural schools.

This study, therefore, aims to explore the effects of a multimodal teaching approach on the development of number sense in Grade 8 learners in two secondary schools within the Ncamagoro Circuit. By implementing a multimodal instructional strategy, this research seeks to enhance learners' numerical understanding, support diverse learning needs, and provide practical insights for teachers and curriculum developers on improving Mathematics instruction in Namibia. The ultimate goal is to empower learners to become confident and flexible problem solvers, capable of applying number concepts meaningfully in real-life and academic contexts.

1.2. Statement of the Problem

Despite ongoing efforts to improve Mathematics education, Mathematics continues to present a learning challenge for many Namibian learners, especially in rural areas like the Ncamagoro Circuit of the Kavango West Region. Many learners continue to demonstrate weak number sense, particularly in areas where instructional practices remain traditional. In the Ncamagoro Circuit of the Kavango West Region, Grade 8 learners often struggle with basic numerical skills such as estimation, ordering numbers, and mental arithmetic skills essential for number sense development. This poor performance is concerning, as number sense forms the foundation for flexible problem-solving and conceptual understanding in Mathematics.

A key factor contributing to this challenge is the dominance of traditional teaching methods that prioritise rote procedures over conceptual understanding for diverse learners. Studies by Jatileni and Neshila (2023) and Abisai, Naukushu, and Kasanda (2019) link these traditional teaching methods to poor learner performance and difficulty in developing mathematical thinking. Similarly, Naukushu (2011) and Potgieter (2015) observed that learners in northern Namibia, particularly in the Oshana region, struggled with number concepts due to limited use of hands-on and visual strategies, while Chirimbana et al. (2024) highlighted how weak early instruction leads to lasting learning gaps. Previous Namibian studies on number sense have primarily focused on lower primary learners, such as Grade 2 (Potgieter, 2015) and Grade 3 (Ndinelago, 2021), or on senior secondary and pre-service levels, including Grade 12 learners (Naukushu, 2011) and final-year pre-service teachers (Courtney-Clarke & Wessels, 2014), leaving a gap at the junior secondary level as none of these studies focused specifically on the Ncamagoro Circuit in the Kavango West Region or Grade 8 which this study aims to address.

While several international and local studies have demonstrated the benefits of multimodal teaching in various subjects, including biology (Ayimbila & Pappoe, 2022), limited research has been done on its application in Mathematics teaching instruction, such as multimodal teaching approach targeting number sense development at the junior secondary level in Namibia. The current study seeks to close this gap and contribute to the growing body of knowledge by investigating the effects of a multimodal instructional approach on Grade 8 learners' number sense development in a rural and under-resourced context. Given the lack of targeted interventions and the reliance on traditional teaching practices in the Ncamagoro circuit, the need for this study is both timely and relevant.

By exploring how multimodal teaching approaches such as visual, auditory, kinaesthetic, and verbal strategies affect learners' understanding of numbers, this study aims to provide practical insights for Mathematics educators and curriculum developers seeking to improve learner outcomes in similar environments.

1.3. Research Questions and Hypotheses

The following research questions and hypotheses served as a guide for this study:

1.3.1. Research Questions

1: What are the effects of a multimodal approach on the development of number sense in Grade 8 learners?

2: How does the multimodal approach affect Grade 8 learners' retention of numerical concepts?

1.3.2. Research Hypotheses

Null Hypothesis 1 (H_{01}): There is no significant difference in the development of number sense between the test scores of learners taught using a multimodal approach and those taught using the traditional approach.

Alternative Hypothesis 1 (H_{11}): There is a significant difference in the development of number sense between test scores of learners taught using a multimodal approach and those taught using a traditional approach.

Null Hypothesis 2 (H_{02}): there is no significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach.

Alternative Hypothesis 2 (H_{12}): There is a significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach.

1.4. Definition of terminologies

Arithmetic refers to basic mathematical operations such as addition, subtraction, multiplication, and division that support estimation, rounding, ordering numbers, and problem-solving (Haimbodi, 2019). In this study, the term arithmetic will be used to refer to basic numerical operations, including addition, subtraction, multiplication, and division, as well as related mental computation and estimation strategies essential for developing number sense.

Effectiveness: This term is understood as the degree to which a method or approach successfully produces a desired result (Schweig, 2019). Effectiveness in this study will refer to how well the multimodal approach (measured on post-test outcomes of learners) improves learners' number sense compared to the traditional teaching approach.

Multimodal Instruction is a form of instruction that involves the use of visual, auditory, kinaesthetic, and symbolic methods to improve learners' understanding and retention of mathematical concepts (Fleming & Baume, 2021). In this study, the term multimodal instruction is used to refer to a teaching approach that integrates multiple modes of communication such as visual, auditory, verbal, and kinaesthetic strategies to enhance learners' understanding and engagement with mathematical concepts.

Traditional Approach: The traditional approach relies on rote learning and direct instruction, where teachers primarily teach with minimal interactive techniques (Clark,

2012). In this study, it serves as a control point for comparing multimodal teaching effectiveness.

Number sense, in this study, refers to the ability to understand, estimate, compare, and flexibly work with numbers in meaningful ways (Naukushu, 2011).

Visual: In this study, "visual" refers to learning strategies that involve sight, such as diagrams, charts, and visual aids, which help learners see patterns, relationships, and quantities in numbers. Visual materials were used to provide concrete representations of abstract mathematical ideas, facilitating learners' comprehension and retention (Fleming & Baume, 2021).

Auditory: "Auditory" learning, as applied in this study, involves the use of sound-based strategies, including verbal explanations, discussions, and auditory feedback. This mode enabled learners to process information through listening, encouraging them to verbalise and reason through mathematical problems, which supports their understanding of numerical relationships and estimation (Fleming & Baume, 2021).

Kinaesthetic: In this study, "kinaesthetic" refers to learning through physical activities, such as hands-on manipulatives, gestures, and movement. Kinesthetic activities allow learners to actively engage with numbers and concepts, building a concrete understanding of mathematical ideas by physically interacting with materials, thus reinforcing their estimation and problem-solving abilities (Fleming & Baume, 2021)

F-value: The F-value in this study calculates the ratio of variance within groups to variance between groups. A high F-value indicates that there are notable differences

between the groups. In the context of this study, F-value was used in one-way/two-way ANOVA analysis (Field, 2018).

t-value**:** In this study, the difference between group means in relation to variability was measured using a t-value. A higher t-value suggests a greater difference between groups. In the context of this study, t-value was used in t-tests for both independent and paired-sample t-tests (Field, 2018).

P-value: A p-value was used in this study to illustrate the likelihood of obtaining the observed outcome in the event that the null hypothesis is correct. A statistically significant result indicates strong evidence against the null hypothesis if $p < 0.05$. It was used to test statistical significance in all tests (Field, 2018).

1.5. Significance of this study

In Namibian contexts, especially in the Ncamagoro Circuit of the Kavango West Region, learners frequently struggle with poor numerical concepts. This study made an effort to address this problem at the two Ncamagoro Circuit schools that were chosen. Basic numerical skills like estimation, mental computation, and number relationships, all necessary for improvement in Mathematics and problem-solving, remain a challenge for many Grade 8 learners. Studies such as that of Jatileni and Neshila (2023) and Abisai, Naukushu and Kasanda (2019) highlight that traditional teaching methods, characterised by rote learning and procedural emphasis, remain dominant in many rural classrooms and have been identified as contributing factors to poor Mathematics performance. The varied learning styles of students are frequently not accommodated by these methods, especially in educational institutions with few resources, such as in the context where this study was conducted.

By exploring the effects of a multimodal teaching approach which integrates visual, auditory, kinaesthetic, and tactile strategies, this study offers a practical framework for enhancing learners' engagement and conceptual understanding of number sense. Although earlier research in the fields of biology (Ayimbila and Pappoe, 2022) and reading comprehension (Boonen et al., 2014) did not focus on Mathematics, their results demonstrate the potential of multimodal strategies to enhance learners' capacity to process information from a variety of sensory inputs.

It is anticipated that the results of this study will give maths teachers in situations similar to the Ncamagoro circuit in the Kavango West Region important information on how to adapt their lessons to accommodate a range of learners' needs and go beyond the conventional teaching methodology. Furthermore, by encouraging the incorporation of multimodal pedagogy into Mathematics education within the framework of this study, the research can contribute to efforts at curriculum reform and professional development. By addressing instructional challenges in remote and resource-constrained Namibian schools like the one where this study was conducted, this research ultimately supports educational equity and improves learner performance in Mathematics. Thus, this study comprises understanding numerical relationships, estimation, mental computation, and flexible problem solving. This study's findings will contribute to the existing knowledge and inform classroom practices, curriculum design, and professional development programmes for Mathematics teachers.

1.6 Limitations

Among this study's limitations are challenges of implementing multimodal strategies in traditional classroom settings. However, the researcher conducted preparation sessions,

including lesson demonstrations, material development, and technology orientation, to ensure the effective application of multimodal strategies in the classroom. Potential variation in learners' responses to different modalities was mitigated by preparing diverse and inclusive instructional materials to cater for individual learning preferences. Some other limitations include financial constraints and transport; hence the researcher conducted the research at nearby schools. Possible unavailability of the participants and refusal of some participants during the time of data collection were addressed through flexible timelines and encouraging active participation, emphasising that the sessions aligned with the Mathematics curriculum and provided learning benefits. Incomplete or uninterested responses from the participants were managed through clear instructions and an engaging process, emphasising the benefits for Mathematics proficiency.

As a result, this study's scope is context-specific and reflects the experiences and outcomes of learners in only two rural school settings. Although the results may offer valuable insights for similar educational contexts, broader generalisations should be approached with caution. Further studies involving more schools and diverse settings are recommended to validate and extend these findings.

1.7. Delimitation

This study was delimited to Grade 8 learners at two secondary schools within the Ncamagoro Circuit of the Kavango West Region. The focus was specifically on the development of number sense through the use of a multimodal teaching approach. Only learners in Grade 8 were included because this stage marks a critical transition where foundational number concepts are expected to support the learning of more advanced

mathematic concepts. This study was further delimited to topics within the number sense domain, such as estimation, numerical relationships, and mental arithmetic.

Additionally, a total population sampling technique was used, meaning all Grade 8 learners from the two schools participated. As such, the findings are context-specific and may not be generalisable to other grades, regions, or school types in Namibia. This study also did not investigate broader mathematical competencies beyond number sense.

1.8. Structure of the thesis

Chapter one introduces this study, highlighting its background and its importance, as well as the context and the problem that gave rise to the significant need for this study. Also, this study hypotheses are also highlighted and explained.

Chapter two focuses on reviewing the literature to determine what research has already been done that relates to this study. The first section will review recent studies that examine how a multimodal approach can help learners develop number sense and how it can be applied to junior secondary education, specifically in Grade 8. This study's theoretical framework will be examined in the second section.

Chapter three outlines the research methodology employed to evaluate the effects of a multimodal approach in developing number sense in Grade 8 learners. The research design, population, sample and sampling procedures, data collection tools, and analysis methods are all covered in more detail in this chapter. In order to ensure the responsible and ethical conduct of the research, the ethical considerations that guided the implementation of this study are also discussed here.

Chapter four presents the findings from quantitative analysis aimed at examining the effects of a multimodal approach on Grade 8 learners' development of number sense. This study employs statistical analyses such as descriptive statistics, t-tests, and ANOVA to assess the effects of a multimodal approach compared to the traditional method in developing learners' number concepts.

Chapter five summarises this study's findings, conclusions, and suggestions on recommendations based on the findings and their discussions.

1.9 Chapter 1 summary

The Chapter summarises this study by providing background, outlining the problem statement, and highlighting the significance of the research study. It also outlined research problems, emphasising challenges learners face in developing number sense skills due to traditional teaching approaches. It highlighted the effects of a multimodal teaching approach in enhancing learners' number sense. Key terms were defined to ensure clarity throughout this study, and the research questions and hypotheses were all clearly stated. The significance of this study was discussed, demonstrating its potential impact on educational practices, particularly in Mathematics education. Lastly, the scope, limitations, and delimitations of this study were detailed, establishing the framework within which this study is conducted. The chapter sets the foundation for subsequent chapters that delve into the theoretical framework, methodology, and findings to analyse the effects of a multimodal teaching approach in developing number sense among Grade 8 learners in Ncamagoro Circuit, Kavango West Region.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

In this chapter, the first section reviewed studies, focusing on number sense development, the use of pre-test, post-test and follow-up assessments, the use of an experimental and a control group and the effects of a multimodal approach in developing number sense in learners over a traditional teaching approach and how it can be used to teach number sense in junior secondary, particularly in Grade 8. The second section will present the theoretical framework on which this study is grounded.

2.2 Literature review

The primary objective of this section is to review the literature in order to determine what previous research has been done that is relevant to this study. Numerous studies have been conducted on number sense development and the application of the multimodal instructional approach, which involves using various manipulatives and modes of representation in Mathematics instruction to foster number sense.

2.2.1 Introduction to the Literature Review

There was a number of changes to Namibia's educational system, including the National Curriculum for Basic Education's (NCBE) introduction of Learner Centred Education (LCE) as a major pedagogical change. The reform places a strong emphasis on the need for teachers to encourage critical thinking, active engagement, and the application of a variety of teaching techniques that take into account the experiences, backgrounds, and learning preferences of their learners. The goal of this change was stated in the Ministry of Education, Arts, and Culture [MoEAC], 2016, to move away from rote memorisation and towards conceptual understanding. The significance of Mathematics teacher

development in Namibia is emphasised by Miranda and Adler (2010), who also stresses the necessity of professional development since it promotes efficient teaching methods.

Research indicates that LCE has not always been implemented consistently in Namibian classrooms. Many teachers, especially in under-resourced rural areas, struggle to apply LCE principles due to limited training, inadequate teaching materials, and large class sizes. Mathematics achievement, especially number sense development, remains low among learners at the junior secondary level. Studies show that poor instructional strategies, especially reliance on traditional teaching methods, are contributing factors to weak number sense development and low performance in Mathematics (Naukushu, 2011; Potgieter, 2015; Hamukwaya, 2019). In rural areas such as Ncamagoro Circuit, where challenges like limited resources and overcrowded classrooms prevail, these problems are more critical (Mubonenwa, Chirimbana, & Mukwambo, 2024). As a result, Mathematics teaching remains largely traditional and fails to accommodate diverse learning needs or promote deeper understanding.

Previous research has largely concentrated on number sense in early grades (Ndinelao, 2021) and senior grades (Naukushu, 2011) and on broader instructional challenges and has not adequately examined multimodal interventions at the junior secondary level, given that Grade 8 is a transitional year that sets the foundation for more advanced Mathematics. Thus, this study investigates the effects of a multimodal approach on number sense development among Grade 8 learners in the Ncamagoro circuit, Kavango West Region, a critical and under-researched cohort in the Namibian context.

2.2.2 Number Sense

Naukushu (2011), states that number sense is the capacity of a learner to comprehend numbers, their magnitude, and their relationships, as well as to apply this comprehension flexibly in various contexts. This study views mental arithmetic, computation, and estimation as crucial components for assessing conceptual understanding and problem-solving skills.

In Namibia, several studies have examined the state of number sense among learners and educators. Naukushu (2011) investigated factors affecting number sense development among Grade 12 learners in the Oshana region. This study revealed that over 50% of learners exhibited numerical deficiencies, which correlated strongly with poor performance in Mathematics. Key contributing factors included inadequate teaching resources, insufficient teacher training, and large class sizes. Potgieter (2015), on the other hand, explored the use of manipulatives in teaching number sense to Grade 2 learners in the Oshana region. Potgieter (2015) emphasises the gradual development of number sense through manipulation, visualisation, and reasoning. The findings indicated that many teachers lacked a proper understanding of number sense and the effective use of manipulatives, leading to poor learner performance. This study recommends enhanced teacher training and resource provision to support number sense development. Further, Naukushu, Kasanda, and Kapenda (2021) examined the role of number sense in the performance of Grade 12 learners. Their research confirmed a strong positive correlation between number sense proficiency and overall Mathematics achievement, reinforcing the need for targeted interventions to bolster number sense skills. Hamukonda and Luneta (2023) also analysed instructional strategies used by junior primary teachers in the Oshana

region. This study found that while teachers employed various methods, there was a reliance on closed questioning and limited use of effective teaching aids, suggesting a need for more dynamic and learner-centred approaches to teaching number sense. Chirimbana, Makaka, and Hilongwa (2024), in their study of early childhood learners in the Oluno Circuit, found that limited exposure to foundational strategies and poor instructional methods contributed to weak number concept development. Although their study focused on early education, their findings highlight the lasting impact of poor number sense on learner performance.

The reviewed literature underscores the critical role of number sense in mathematical achievement and highlights challenges in its development within the Namibian education system. Given the identified gaps, particularly in the application of effective teaching strategies and resources, this study aims to investigate the effects of a multimodal teaching approach on number sense development among Grade 8 learners. This study seeks to enhance learners' numerical understanding and address the persistent challenges outlined in previous research by integrating visual, auditory, and kinaesthetic learning modalities.

2.2.3 Experimental and Control Groups

In quasi-experimental research designs, experimental and control groups are essential elements that allow researchers to compare the effects of an intervention to a baseline condition. Creswell (2012), notes that the experimental group receives the treatment or intervention, while the control group does not, allowing for the assessment of causal effects by comparing outcomes between the two groups. Charles and Mertler (2002) further emphasise that these groups are particularly useful in quasi-experimental design when random assignment is not feasible, as is often the case in natural educational

settings. The use of such groups helps control for confounding variables and enhances the internal validity of this study by isolating the impact of the independent variable, in this case, the multimodal teaching approach. This makes them highly relevant in educational research, where randomised control trials may be impractical due to ethical, logistical, or institutional constraints.

In Namibian Mathematics education research, the use of experimental and control group designs has become increasingly relevant for evaluating the impact of specific teaching interventions. Several recent studies have effectively used this approach to assess instructional innovations.

For instance, in order to assess how mental arithmetic techniques affect learners' numerical fluency, Haimbodi (2019) used a quasi-experimental design with both experimental and control groups. The results demonstrated significant improvements in the experimental group, reinforcing the instructional value of structured mental arithmetic integration. Similarly, Shalonda and Iipinge (2024) compared the performance of learners taught using visual and concrete fraction models with those receiving conventional/traditional instruction. The experimental group outperformed the control group in post-intervention assessments, illustrating the effectiveness of model-based learning in enhancing conceptual understanding of fractions. Abiatal and Howard (2020), in their study, also employed an experimental design with the experimental and control groups to assess the role of assistive technology in supporting Mathematics learning. Their findings showed that learners who received instruction using technology-based tools demonstrated greater engagement and improved performance compared to those in the control group.

These studies demonstrate how useful experimental and control group designs are for gauging the effects of pedagogical innovations in Mathematics instruction in various Namibian contexts. Based on this framework, the current study used a quasi-experimental design with experimental and control groups to evaluate how a multimodal teaching strategy affects Grade 8 learners' number sense development in the Ncamagoro Circuit, Kavango West Region. This design enables a direct comparison between learners exposed to the intervention (multimodal instruction) and those receiving traditional instruction.

2.2.4 Pre-test, Post-test, and Follow-Up Assessments

Pretests and posttests are fundamental components of quasi-experimental research designs, serving to measure the impact of an intervention by assessing participants' performance before and after the treatment. By creating a baseline, a pretest enables researchers to ascertain the dependent variable's initial state. In this study, as highlighted in Charles and Mertler (2002), the two groups are given a pretest to help establish their equivalency prior to introducing the experimental treatment. A posttest, administered after the intervention, evaluates any changes or effects attributable to the treatment. Follow-up assessments, conducted after a certain period post-intervention, help in understanding the long-term effects and retention of the treatment outcomes.

Creswell (2012) emphasises that these assessments are crucial for determining the effectiveness of interventions, especially when random assignment is not feasible. They allow for the comparison of groups and the assessment of changes over time, enhancing the internal validity of this study. Charles and Mertler (2002) also highlight the importance of these measures in educational research, noting that they provide a structured approach to evaluate instructional strategies and their outcomes

Pretest and posttest assessments are widely used in educational research to evaluate the effectiveness of instructional interventions. They provide a structured way to measure learning outcomes and compare the impact of different teaching strategies. In Namibia, although fully controlled experiments are rare, some researchers have implemented pretest-posttest designs within quasi-experimental frameworks to assess Mathematics learning outcomes.

Haimbodi (2019) conducted a doctoral study that explored the incorporation of mental arithmetic into primary school Mathematics in the Oshana Region. This study used both qualitative and quantitative methods, including a quasi-experimental control group approach with pretest and posttest instruments. These tests were designed to evaluate learners' mental computation skills in basic operations such as addition, subtraction, multiplication, and division. The results showed notable improvements in learners' ability to apply mental strategies for arithmetic, indicating the effectiveness of structured mental arithmetic integration.

Additionally, in the Onankali Circuit, a pretest-posttest quasi-experimental design was employed by Shalonda and Iipinge (2024) to compare the effectiveness of teaching fractions using models versus traditional textbook methods. Learners in the experimental group, who were taught using area and length representations, significantly outperformed those taught through conventional approaches. This further supports the value of using multimodal and visual strategies to enhance conceptual understanding. Naukushu (2011) employed pretest-posttest instruments to assess number sense among learners, revealing variation in outcomes despite not using a full experimental design. The assessment tool, originally developed by McIntosh et al. (1992), was adapted to suit the Namibian context,

enabling meaningful benchmarking of learners' number sense. Similarly, Courtney-Clarke and Wessels (2014) adapted number sense assessment items for Namibian pre-service teachers by localising content to improve relevance and accessibility. Building on these approaches, the present study employs a similar standardised and contextually adapted instrument to measure changes in number sense before and after the intervention, thereby ensuring reliability and comparability with earlier studies conducted in Namibia.

These studies demonstrate the effectiveness of using pretest and posttest designs to assess the impact of pedagogical strategies on learner performance. The current study adopts a similar approach by using standardised instruments to evaluate the effects of a multimodal teaching strategy on Grade 8 learners' number sense in the Ncamagoro Circuit. This design allows for a robust evaluation of learning outcomes and provides empirical evidence for enhancing Mathematics instruction in rural Namibian classrooms.

2.2.5 Traditional Teaching Approach

The traditional teaching approach, often characterised by teacher-centred instruction, direct explanation, and rote learning, emphasises content delivery and procedural fluency. Its primary strength lies in its ability to cover a wide syllabus efficiently and maintain classroom order, particularly in large and resource-limited settings. However, this approach tends to limit learner engagement, critical thinking, and conceptual understanding, as it offers few opportunities for exploration, discussion, or the application of mathematical concepts in real-life contexts. As a result, it may hinder the development of deeper mathematical reasoning and adaptive problem-solving skills essential for 21st-century learners.

Example: In the lesson, estimation of large quantities was taught through direct instruction using chalkboard examples. The teacher explained how to round numbers to the nearest ten, hundred, or thousand using numeric examples only (e.g., 348 ≈ 350). Learners followed along by copying steps from the board and completing textbook exercises independently. No visual aids such as number lines or rounding charts were used, and learners were not engaged in hands-on activities or peer discussion. The lesson focused primarily on procedural accuracy and written practice, with minimal opportunities for sensory engagement or conceptual exploration.

Traditional teaching characterised by rote learning, algorithmic drills, and teacher-centred instruction continues to dominate Namibian Mathematics classrooms. Mwazi et al. (2024) identified this model as a key factor in learner disengagement and poor Mathematics performance in the Zambezi region. Similarly, studies by Jatileni and Neshila (2023) and Sibuku and Mukwambo (2019) argue that teacher-led instruction, which limits learners' opportunities for engagement and exploration, restricts conceptual development in key mathematical areas. While not focused on number sense specifically, these studies reinforce the broader instructional challenges that contribute to poor mathematical outcomes.

The traditional teaching method has been scrutinised for its limitations in promoting deep understanding and critical thinking in Mathematics education. While traditional methods can efficiently cover a standardised curriculum, they often fail to cater to diverse learning styles and do not encourage active engagement with the material. This flow of information from teacher to learner can hinder active learning and the development of problem-solving

skills. This suggests that reliance on traditional methods may not be the most effective strategy for enhancing student outcomes in Mathematics.

In the Namibian context, challenges such as inadequate teacher training, lack of resources, and large class sizes contribute to the persistence of traditional teaching methods. Mwazi et al. (2023) note that even when teachers are aware of learner-centred approaches, implementation is often hindered by systemic issues, leading to continued reliance on teacher-centred instruction, which is more of a traditional approach in this context.

A change to more interactive pedagogies in Mathematics education is imperative, as evidenced by the body of research from both domestic and foreign studies. These studies support the larger instructional issues that lead to poor results, even though some of them were not especially focused on number sense. Adopting approaches that promote active learning, critical thinking, and problem-solving is essential for improving learner engagement and achievement, particularly in contexts like Namibia where traditional methods have shown limited effectiveness.

2.2.6 Multimodal Teaching Approach

The multimodal teaching approach involves the integration of multiple sensory modes, such as visual, auditory, kinaesthetic, and tactile elements, to present instructional content in varied ways that align with diverse learner preferences. Its strength lies in promoting engagement, enhancing conceptual understanding, and supporting differentiated learning (Mayer, 2009). In a study on biology education, for instance, Ayimbila and Pappoe (2022) showed that combining tactile and visual materials enhanced learner retention and participation. Although the findings are subject-specific, they are pedagogically relevant

and applicable to the teaching of Mathematics. Similarly, multimodal instruction is useful for teaching complex subjects like Mathematics because, when properly aligned, it reduces cognitive load (Lee & Kalyuga, (2015).

> *In my study for example, when estimation of large quantities was taught, learners were first shown a short video demonstrating estimation in real-life scenarios (visual and auditory). This was followed by hands-on group activities using jars filled with counters, where learners physically manipulated items to make approximate counts (kinaesthetic). Learners then recorded their estimates and justified them through peer discussions (verbal). A number line chart and rounding table were displayed to aid visual referencing, and the lesson concluded with guided practice exercises combining visual prompts and oral questions. This sequence allowed learners to engage multiple senses, reinforce understanding, and build mental strategies, in contrast to the control group, which only received textbook-based instruction and explanation from the researcher.*

The lesson integrated visual, auditory, and kinaesthetic elements to support number sense development, and learners were engaged actively throughout the lesson.

The relevance to the current study lies in the approach's potential to support the development of number sense, a concept that requires both abstract reasoning and concrete understanding. In under-resourced contexts like rural Namibia, where learners often struggle with traditional one-dimensional instruction, a multimodal approach can offer practical, inclusive, and conceptually rich learning experiences. Its limitations include the need for careful instructional design to prevent cognitive overload and the difficulty of resource availability, particularly in under-resourced settings like rural

Namibian schools. However, its implementation must be context-sensitive. Multimodal instruction can cause learning to become fragmented or divert attention from important ideas if it is not properly planned.

The use of multimodal teaching approaches that integrate visual, auditory, tactile, and kinaesthetic elements has gained increasing recognition in international education research as a means to enhance learner engagement and conceptual understanding. This study was started because the systematic application of multimodal instruction in Mathematics is still understudied in Namibia, especially at the junior secondary level in the Ncamagoro circuit.

Added to that, Ayimbila and Pappoe (2022), in a study conducted in biology education, found that learners benefitted significantly from lessons incorporating visual, verbal, and tactile elements. Though not specific to Mathematics, their findings affirm the general effectiveness of multimodal strategies in enhancing learner engagement and knowledge retention. This is supported by literature; for instance, Moreno and Mayer (2007) explain that multimodal learning aligns with the cognitive theory of multimedia learning, which posits that information presented through multiple sensory channels facilitates deeper cognitive processing and long-term retention.

In Namibia, Ndinelago (2021) conducted a study with Grade 3 learners using the abacus as a visual and tactile tool to teach number sense. This study showed measurable improvements in learners' understanding of numerical relationships, illustrating how concrete visualisation tools support abstract mathematical thinking. Likewise, Potgieter (2015), in the Oshana Region, found that learners who engaged with manipulatives such

as counters and number lines demonstrated greater numerical fluency and conceptual understanding compared to those exposed to traditional teaching methods alone.

Further afield, Boonen et al. (2014) demonstrated that visual spatial strategies significantly enhance performance in mathematical word problems, particularly among learners with lower prior achievement. Their study underscores the value of visual and interactive representations in supporting reasoning and comprehension in Mathematics. Lee and Kalyuga (2015), drawing on cognitive load theory, argue that multimodal instruction, particularly when well integrated, can reduce extraneous cognitive load and increase meaningful learning, especially in complex subjects like Mathematics. Their findings support the notion that multimodal teaching is not merely a tool for engagement but a strategy grounded in learning.

Although limited in scope, the studies by Naukushu (2011) and Potgieter (2015) suggest that traditional approaches do not sufficiently support the development of number sense. Multimodal teaching offers a more learner-centred alternative that can address these limitations by catering to varied learning preferences and promoting active cognitive involvement.

These studies suggest that multimodal instruction holds strong potential to improve Mathematics outcomes in the Namibian context. The current study aims to extend this understanding by applying a multimodal teaching approach to Grade 8 learners in the Ncamagoro Circuit, evaluating its effect on number sense development within a rural junior secondary school setting.

2.2.7 Traditional and Multimodal Teaching Approaches in Developing Number Sense

Although few Namibian studies have conducted direct comparisons between traditional and multimodal teaching approaches, available local and international research suggests notable differences in their impact on the development of number sense. Consider the following lessons in different approaches:

1. *Estimating Money (Traditional Approach)*

   In the traditional approach, the teacher explained estimation procedures by writing example prices on the chalkboard (e.g., N$9.50, N$12.75) and demonstrating how to round them to the nearest whole number. Learners copied the steps into their exercise books and completed similar examples individually, following a set formula provided by the teacher. There was minimal use of visual aids or interaction, and the focus remained on procedural accuracy rather than conceptual understanding. Learners had limited opportunity to engage with physical materials or apply estimation in real-life contexts.

2. *Estimating Money (Multimodal Approach)*

   To teach estimation of money, learners were shown visual images of everyday grocery items with price tags (e.g., N$9.50, N$12.75). In small groups, they used mock Namibian banknotes to role-play shopping and were asked to estimate the total cost of selected items. This activity engaged visual and kinaesthetic modes, while group discussions allowed learners to explain and justify their rounding strategies verbally. The teacher facilitated the process through guided questions,

reinforcing learning through auditory input. This hands-on, interactive lesson helped learners approximate totals without relying solely on calculation.

From the given examples, the multimodal lesson on estimating money engaged learners through visual aids, hands-on activities, and group discussions, allowing them to interact with prices and mock currency in a realistic shopping scenario. This approach encouraged active learning and conceptual understanding. In contrast, the traditional lesson was teacher-centred, relying on board demonstrations and written exercises with limited learner interaction. While the traditional method focused on procedural steps, the multimodal approach promoted deeper engagement and practical application of estimation skills.

Boonen et al. (2014) demonstrated that learners exposed to instruction involving visual spatial strategies and multimodal representations performed significantly better on mathematical word problems than those taught using conventional methods. Similarly, Jacobson (2023), in a study on elementary education, found that multisensory instructional approaches improved learners' arithmetic fluency and engagement when compared to rote-based teaching methods.

In the Namibian context, while direct comparative studies remain limited, available evidence points to the deficiencies of traditional instruction and the potential benefits of multimodal strategies. Courtney-Clarke and Wessels (2014) investigated the number sense of final-year pre-service teachers and found significant gaps in their conceptual understanding, attributing this partly to procedural and rote-based instructional experiences during their own schooling. Although this study did not implement an intervention, it highlights the long-term limitations of traditional teaching methods.

Hamukwaya and Haser (2021) further noted that many Namibian teachers maintain deficit beliefs about learners' capabilities in Mathematics, often resulting in low expectations and reliance on highly structured, non-interactive instructional methods. Such approaches limit learners' opportunities for active engagement and flexible problem-solving, which are critical for number sense development. This concern was echoed by Mubonenwa, Chirimbana, and Mukwambo (2024), who reported that junior secondary Mathematics classrooms in the Zambezi Region remain largely teacher-dominated, contributing to persistent learner underperformance.

On the other hand, Potgieter (2015) and Ndinelago (2021) provided promising evidence of how visual and hands-on tools, such as manipulatives and abaci, enhanced number sense among early grade learners. Although these studies did not involve direct comparisons with control groups using traditional methods, their findings underscore the conceptual advantages of learner-centred, multimodal instruction.

Therefore, this study contributes distinctively by directly comparing the effectiveness of traditional and multimodal approaches in the development of number sense among Grade 8 learners. It aims to provide empirical evidence to support a shift towards more interactive and inclusive pedagogies within the Namibian Mathematics education system, particularly in under-resourced rural contexts like the Ncamagoro Circuit.

2.2.8 Implications for the Current Study in the Namibian Context

The reviewed literature confirms that number sense is a foundational aspect of mathematical proficiency, encompassing skills such as estimation, numerical reasoning, mental arithmetic, and flexible problem-solving. Despite its significance, number sense

remains underdeveloped among many Namibian learners, primarily due to the continued use of traditional, teacher-centred instructional methods (Naukushu, 2011; Potgieter, 2015; Mubonenwa et al., 2024). These approaches often emphasise rote learning and procedural fluency at the expense of conceptual understanding and learner engagement.

Although some local studies have explored elements of number sense at the early primary level (Potgieter, 2015; Ndinelago, 2021) or examined the competencies of pre-service teachers (Courtney-Clarke & Wessels, 2014), there is a notable absence of research focusing specifically on the effects of multimodal instructional strategies on number sense development among Grade 8 learners in rural Namibian contexts. This is a critical gap, particularly in regions such as the Ncamagoro Circuit, where limited resources and overcrowded classrooms exacerbate learning challenges.

Added to that, literature consistently supports the use of multimodal teaching approaches to enhance learners' conceptual understanding, accommodate diverse learning preferences, and foster deeper cognitive engagement (Mayer, 2009; Boonen et al., 2014; Lee & Kalyuga, 2015). However, empirical data from the Namibian junior secondary context is lacking.

This study seeks to address that gap by implementing a quasi-experimental design to assess the impact of a multimodal instructional intervention on the number sense of Grade 8 learners in two rural schools. The findings are expected to provide practical recommendations for improving Mathematics teaching, contributing to teacher development, and guiding curriculum reforms focused on inclusive, learner-centred pedagogy in Namibia, such as a multimodal approach to enhance Mathematics learning

outcomes. Ultimately, this study aims to inform teacher training programmes and policy decisions that support equity and effectiveness in Namibian Mathematics education.

2.3 Theoretical framework

This study is grounded in logical constructivism, a theory of learning rooted in the ideas of L.E.J. Brouwer, influenced by the theory of Jean Piaget of cognitive development constructivism, which emphasises that knowledge is actively constructed by learners through logical thinking and meaningful experiences (Brouwer, 1907). This theory is more suited for Mathematics education, particularly number sense, as it integrates logic with sensory learning experiences (Brouwer, 1907; Piaget, 1971). Logical constructivism posits that learners build knowledge structures by engaging in problem solving, reasoning, and reflecting on their experiences, rather than passively absorbing information. In Mathematics education, this theory supports the view that learners develop mathematical concepts, such as number sense skills, through a dynamic process of constructing understanding based on interaction with their environment and instructional activities.

Logical constructivism theory allows learning to be effective when it involves active participation, where learners manipulate information and relate new knowledge to prior understanding (Brouwer, 1907; Piaget, 1971). This study applies the theory of logical constructivism by integrating a multimodal approach to teaching number concept skills, aiming to enhance number sense through hands-on activities, visual aids, and digital resources. Logical constructivism informs this study by emphasising active knowledge construction through reasoning, helping learners develop number sense by engaging in problem-solving and logical connections (Brouwer, 1907; Piaget, 1971). A multimodal instructional approach aligns with the logical constructivist view, as it provides diverse

ways for learners to engage with mathematical concepts, thereby facilitating deeper comprehension with some improved number sense abilities. Martin and Jessie (2010), stated that logical constructivism places a strong emphasis on experiential learning and the creation of knowledge. McLeod (2023) suggests learners build knowledge by integrating new experiences into their existing mental structures and interacting with their learning environment. This approach is common in many forms of constructivism, which emphasise the active involvement of learners. However, logical constructivism, in particular, focuses on the application of structured reasoning and logic as essential components of this knowledge-building process. Unlike other constructivist approaches, which may primarily emphasise sensory experiences, logical constructivism integrates logical reasoning into learning, especially in abstract fields like Mathematics (Brouwer, 1907; Main, 2021; Piaget, 1971). Under logical constructivist theory, learners can construct their understanding of number concepts by engaging in activities that involve various learning techniques, such as visual, auditory, and kinaesthetic modes, while also applying logical thinking to connect new and existing knowledge (Main, 2021).

The theory of logical constructivism emphasises the importance of metacognition and reflection in the process of learning, which entails motivating learners to assess and track their own learning procedures and draw connections between previously learnt material and new information (Brouwer, 1907; Piaget, 1971). Teachers can help learners develop metacognitive skills and strategies that will help them develop and retain number sense (Brau, 2020).

Logical constructivism permits the use of visual, auditory, and kinaesthetic learning methods, which are the actual scenarios that help learners learn mathematical concepts

(Maryam et al., 2011). Since the logical constructivism theory backs up the idea that using visual, auditory, and kinaesthetic presentations during instruction helps learners retain information for extended periods of time and process more information in working memory, it is considered necessary for this study. This is crucial in the development of number sense, as learners need to manipulate numerical concepts and make sense of them in various ways. Given that information is presented to learners in a variety of ways (audio, visual, and kinaesthetic), logical constructivism also aids in meeting their varied learning needs. By employing a multimodal approach, facilitators are able to engage learners more effectively, enabling them to build mathematical concepts such as number sense through varied and dynamic interactions. Additionally, the theory provides support by allowing facilitators to present ideas in different modes, which helps to capture the learners' attention during the instructional process, thus facilitating the achievement of the lesson's objectives.

This theoretical perspective underpins this study because logical constructivism aligns closely with the aims and design of this research. Since the study investigates how learners develop number sense through varied sensory and logical instructional strategies, logical constructivism provides a suitable foundation by emphasising active, structured knowledge construction. The multimodal instructional approach used in this study reflects the core principles of logical constructivism by engaging learners meaningfully with content, make logical connections, and construct their own understanding through diverse modes of representation. Thus, this theory not only supports the intervention but also offers a coherent framework for interpreting how and why the intervention may affect learners' development of number sense. It therefore provided a basis for the researcher to

enquire into the effect of a multimodal approach in developing number sense to Grade 8 learners.

2.4 Chapter 2 summary

This Chapter reviewed literature highlighting the impact of multimodal instructional approaches on the development of number sense. Existing studies suggest that traditional teaching methods often overlook learners' diverse learning styles, which can hinder mathematical understanding. In contrast, multimodal strategies integrating visual, auditory, and kinaesthetic techniques have been shown to enhance learner engagement, comprehension, and retention of numerical concepts.

Logical constructivism was identified as a suitable theoretical framework for this study, as it emphasises active knowledge construction through meaningful learning experiences. The reviewed literature supports the view that learners exposed to multimodal instruction tend to demonstrate stronger performance in mathematical tasks, particularly in understanding number relationships.

Despite these literature findings, there is still a need for more empirical research on the use of multimodal approaches in the Namibian context. This study seeks to contribute to that gap by evaluating the effects of a multimodal instructional approach on number sense development among Grade 8 learners in the Ncamagoro Circuit of the Kavango West Region.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction

The research methodology used in this study to assess how a multimodal approach affects Grade 8 learners' number sense development is outlined in this chapter. The aim of this study was to examine how a multimodal instructional approach affects learners' growth in mathematical comprehension and number sense abilities. The research design, population, sample, sampling procedures, data collection methods, research instruments, and data analysis techniques of this study are also covered in this chapter. In order to ensure the responsible and ethical conduct of the research, the ethical considerations that guided the implementation of this study are also discussed. Through these methods, this study provides insightful information into how different instructional approaches foster improved mathematical understanding, particularly in the development of number sense in Grade 8 learners.

3.2 Research paradigm

This study is grounded in the post-positivist research paradigm, which emphasizes the use of scientific methods and empirical data to understand and explain phenomena, while acknowledging that all observation is fallible and influenced by context (Nelson, 2014; Creswell & Creswell, 2018).Post-positivism acknowledges that while the effect of an intervention to develop number sense can be objectively measured, our understanding of the results is influenced by learners' contexts and prior experiences (Creswell & Creswell, 2018). This paradigm supports systematic experimentation that analyses pre- and post-test scores to assess the development of number sense while recognising variability due to the multimodal teaching method. It emphasises rigorous empirical methods to minimise

bias and acknowledges the fallibility of observations, allowing for flexible interpretation of findings (Siegler & Lortie-Forgues, 2014). Unlike positivism, which assumes an objective reality (Phillips & Burbules, 2000), post-positivism acknowledges the need for critical data analysis and human fallibility. In line with logical constructivism (Brouwer, 1981), it acknowledges learners' cognitive processes in the development of number senses while promoting structured mathematical learning through quasi-experimental techniques and empirical validation. This study adopts a post-positivist research paradigm to guide its inquiry, based on the belief that reality can be measured objectively but is also influenced by context and human experience. Post-positivism is well suited for quasi-experimental designs involving interventions, as it allows for the use of quantitative data to test hypotheses while acknowledging potential limitations and biases in measurement (Creswell & Creswell, 2018). This paradigm supports the study's aim of evaluating the effect of a multimodal intervention in developing number sense among Grade 8 learners, while also examining the results within the context of classroom learning and learner diversity.

3.3 Research design

This study employed a quasi-experimental design to gather data and draw conclusions. Quasi-experimental design is a scientific approach that investigates causes and effects between variables (Mitchell, 2015). Participants in quasi-experiments are not randomly assigned to groups, in contrast to true experimental designs. Instead, participants are naturally assigned to different conditions based on pre-existing characteristics, which makes it more feasible in natural settings (Shadish et al. 2002). This study involved a sample of Grade 8 learners at the two secondary schools in Ncamagoro Circuit. Two

groups of participants were formed: an experimental group that received multimodal teaching (involving visual, auditory, and kinaesthetic approaches) and a control group that received a traditional teaching approach (Mitchell, 2015).

Participants were grouped based on natural settings within their schools, without random selection, which is a characteristic of quasi-experimental designs. This makes this study a quasi-experiment, as it tests causal relationships in a more natural pre-existing conditions, less regulated setting as opposed to an actual experiment (Mitchell, 2015; Shadish et al., 2002). These groups' results from pre-test, post-test, and follow-up assessments were compared in order to ascertain how these methods affected test scores (an independent variable) and learners' retention of the number concepts (a dependent variable).

3.4 Population

The target population for this study comprised all 204 Grade 8 learners enrolled in the four secondary schools offering Grade 8 in the Ncamagoro Circuit, Kavango West Region, Namibia.

3.5 Sample and Sampling Procedures

This study employed purposive sampling to select two secondary schools from the four that offer Grade 8 in the Ncamagoro Circuit, Kavango West Region. The selection was based on the fact that each of the two schools had exactly 30 Grade 8 learners, which made them suitable for forming comparable experimental and control groups within a quasi-experimental design.

All 30 learners from each of the selected schools were included, resulting in a sample size of 60 learners representing approximately 30% of the total Grade 8 population (204 learners). This approach is consistent with total population sampling, a form of purposive sampling used when the entire population within a defined group is small, manageable, and relevant to the research focus (Etikan et al., 2016; Lund Research Ltd., 2012). The participants were therefore assigned into experimental and control groups within their schools.

3.6 Research Instruments

To assess participants' number sense abilities, a series of carefully designed research instruments were employed, consisting of a pre-test, a post-test, and a follow-up assessment task (attached as appendices 1, 2, and 3). These tools, as stipulated in Charles and Mertler (2002), were intended to measure both the immediate and long-term effect of the intervention on learners' understanding of numerical concepts. In addition, 3 lessons were prepared for each group and delivered by the researcher.

The purpose of the pre-test was to determine the baseline level of the learners' number sense abilities at the start of this study and also to establish equivalency for nonequivalent groups to be studied, the experimental and control groups, prior to the introduction of the intervention (Charles & Mertler, 2002). Pre-test included questions focused on estimation and problem-solving concepts, which are critical components of number sense. The pre-test results served as a baseline against which the intervention's effectiveness could be evaluated. A post-test was carried out to measure the intervention's immediate effects after the multimodal approach was carried out (Creswell, 2012). The post-test replicated the content of the pre-test, focusing on estimation and problem-solving tasks. To find out how

much the learners' number sense skills had improved, this study compared the pre-test, post-test results and follow up assessment (delayed post-test). To assess the long-term retention and application of the skills acquired through the multimodal approach, follow-up assessment (delayed post-test) was conducted four weeks after the post-test. These assessments included more advanced estimation and problem-solving tasks, designed to challenge the learners and assess their ability to apply their skills in new contexts. This task provided additional insights into the intervention's long-term impact, measuring the degree to which participants retained and applied the number concepts beyond the immediate intervention period.

Overall, the combination of the assessments allowed a thorough evaluation of the multimodal approach's impact on developing number sense in Grade 8 learners. This comprehensive data collection strategy ensured that this study could capture both immediate improvements and long-term benefits, offering a thorough comprehension of the intervention's effects.

In this study, the use of the pre-test, post-test, and delayed post-test allowed for a systematic and objective evaluation of the multimodal approach's effect in developing number sense among Grade 8 learners. By comparing learners' performance across these three assessment points, the study was able to measure not only immediate gains but also the retention and transfer of number sense skills over time. This approach provided robust evidence on the impact of the intervention within the specific context of the Ncamagoro Circuit schools, thereby fulfilling the study's aim to assess both short-term and long-term outcomes of multimodal instruction on learners' numerical understanding.

3.7 Validity and reliability of Research instruments

Validity and reliability issues were carefully considered in order to guarantee that the research tools (pre-test, post-test, and follow-up assessment task) continuously and accurately assessed participants' number sense skills.

3.7.1 Validity

Creswell (2014) defines validity as the extent to which an instrument accurately measures the concepts it is intended to assess in this case, number concepts. To enhance content validity, the test items were designed to cover essential aspects of number sense, such as numerical relationships and estimation skills, aligning closely with established curriculum standards and learning objectives. Construct validity was also ensured by designing tasks that specifically measure cognitive and practical understanding of number concepts, which are central to the intervention's focus. Moreover, the follow-up assessment strengthened predictive validity, as it measured the retention and application of number sense over time, providing insights into the intervention's long-term impact.

3.7.2 Reliability

Reliability is used to refer to the uniformity and constancy of this study's instruments for repeated measurements (Creswell, 2014). To enhance internal consistency, each assessment (pre-test, post-test, follow-up task) was reviewed and quality-checked by this study's supervisor, carefully piloted and revised to ensure clarity and reduce ambiguity in questions, ensuring that learners' responses reliably reflect their understanding of number sense. Additionally, test-retest reliability was supported by the consistent use of these instruments across multiple time points of assessments, allowing the researcher to assess

whether the results were stable over time. The research instruments therefore offered a strong and reliable foundation for assessing the intervention's immediate and long-term effects on participants' number sense skills.

3.8 Data collection procedure

The study began by administering a pre-test to both the experimental and control groups to determine learners' initial level of number sense and to establish the equivalency of the two groups before the intervention (Charles & Mertler, 2002). Following this, the intervention phase was conducted over five days, during which the control group received traditional instruction, while the experimental group was taught using the multimodal approach. Both groups participated in three lessons delivered by the researcher. After the completion of these lessons, a post-test containing the same tasks as the pre-test was individually administered to both groups to assess the immediate effect of the teaching methods. Finally, to evaluate the long-term retention of number sense skills, a follow-up assessment (delayed post-test) incorporating content from the pre-test and post-test was conducted four weeks later. This systematic procedure allowed for a comprehensive evaluation of both the short-term and lasting impacts of the multimodal instruction compared to traditional teaching.

3.9 Data analysis

Data collected from the pre-test, post-test, and follow-up assessments were examined with SPSS. In SPSS, data files were organised by rows that represent individual respondents to tests and columns (variables) that represent responses to each question asked in the tests (Creswell, 2012). Descriptive statistics were run in SPSS for each assessment separately to provide information on measures such as five-point summary, mean, and

standard deviation. Descriptive statistics were employed; the mean scores from the pre-test and post-test assessments were compared using a paired sample t-test and an independent t-test in SPSS. This test assessed whether scores before and after the intervention differed in a way that was statistically significant. The data from all three assessments (pre-test, post-test, and follow-up assessment/delayed post-test) were also analysed using a one-way repeated ANOVA, which also helped identify any significant variations in mean scores between the three time points (Gravetter & Wallnau, 2021). These tests assessed whether the experimental and control groups' performance differed from one another or whether the intervention had an impact on this study population (Creswell, 2012). The formulated null hypotheses, H_{01} and $H_{02,}$ were tested to ascertain whether test performance differed between the experimental and control groups.

Descriptive statistics, paired sample t-tests, and independent sample t-tests were used in the analysis, which was conducted using SPSS software, to compare group performance and look for any notable variations in results between the multimodal instructional approach and traditional instructional approaches. A significance threshold of $p = 0.05$ was established, aligning with standard research practices to ensure that observed differences are statistically significant (Field, 2018). The statistical tests run in SPSS addressed various aspects of the research questions, each chosen to analyse specific components of the data and draw meaningful conclusions about the impact of the multimodal instructional approach:

3.10 Research Ethics

Research ethics refers to a set of guidelines for the responsible conduct of research, and it is an important part of a study (Kalichman, 2010). In this study, the researcher sought

ethical approval from the University of Namibia Research Ethics Committee (UREC) to guarantee that the research complied with ethical standards that safeguard the participants' rights, identities, and welfare. Participants voluntarily signed consent forms after being informed of this study's purpose, the procedure, and the reimbursements (Creswell & Creswell, 2018). For minors, assent forms were signed by their legal guardian to ensure that the child understood and agreed to participate (Israel, 2015). Prior to starting this study in schools, the researcher also obtained formal written approval from the Regional Director of Education, the Inspector of Education for Ncamagoro Circuit, the Executive Director of the Ministry of Education, Arts, and Culture, and the principal of the schools. The researcher ensured ethical guidelines by obtaining informed consent, ensuring participant confidentiality through secure data storage, and promoting honesty by accurately reporting results without manipulation or bias (Bryman, 2016). The researcher ensured that participants were informed of their voluntary participation in this study, and they were not forced if they chose not to participate or withdrew from this study. Names were kept anonymous, and the information gathered was kept private and locked away. Five years after this study was successfully finished, the data collected will be destroyed. The researcher also ensured post-intervention support to the control group to ensure they also benefit from the improved teaching method.

3.11 Chapter 3 summary

This chapter outlined the research methodology used to examine how a multimodal instructional approach affected the number sense development of Grade 8 learners. A quasi-experimental design was employed, with participants divided into control and experimental groups to assess the effects of multimodal instruction compared to

traditional teaching methods. This study used pre-tests, post-tests, and follow-up assessments/delayed post-test to measure learners' progress over time, ensuring a comprehensive evaluation of their number sense development.

This study employed purposive sampling to select the two schools and total population sampling within each school. The chapter also discussed how the research ethics were taken into consideration by adhering to research ethics standards.

This Chapter established a foundation for analysing the effects of multimodal instructional strategies in Mathematics education. The findings from the data presentation and analysis in the next chapter will determine whether multimodal approaches significantly improve number sense and provide empirical evidence to support their implementation in Namibian classrooms.

CHAPTER 4: PRESENTATION AND DISCUSSION OF RESULTS

4.1 Introduction

This chapter presents the findings of the study that examined the impact of a multimodal instructional approach on the development of number sense among Grade 8 learners. The results are organised according to the statistical tests used to answer the research questions outlined in Chapter 1. The chapter also compares the performance of the experimental and control groups to determine the effectiveness of the multimodal approach in supporting number sense development.

4.2 Presentation of results

This results, which sought to investigate how a multimodal approach affected Grade 8 learners' number sense development, are presented in this section. Data were collected through pretests, posttests, and follow-up assessments. The analysis was conducted using SPSS, employing statistical techniques. The results offer insights into whether the multimodal approach enhances number sense in learners and provide a deeper understanding of its effects. These findings are significant, contributing to the body of knowledge on Mathematics teaching strategies and offering potential implications for improving Mathematics education. Raw data (test scores) are shown in Appendix 17 and box and whisker plots in Appendix 18, respectively.

Table 1: Shows Pre-test for both groups (control and experimental)

	Control group pre test	Experimental group pre test
Mean	12.57	12.47
Std. Deviation	3.53	2.69
Variance	12.46	7.22
Minimum	5	8
Maximum	20	16
Quartile 1	10.25	10
Quartile 2	12	12.5
Quartile 3	14.75	15

The results of the above table demonstrate that, prior to the intervention, the experimental group had a mean score of 12.47 (with a SD of 2.69), while the control group had a mean score of 12.57 (with some variation, as indicated by an SD of 3.53). This means that the starting levels for learners in both groups were basically the same, with only a very small difference between them as indicated by the mean scores.

Table 2: Independent t-test summary of post-test comparison of both groups (control group and experimental)

	Control group post test	Experimental group post-test
Mean	15	17.93
Std. Deviation	4.63	2.79
Variance	21.45	7.79
Minimum	7	14
Maximum	26	24
Quartile 1	12	16
Quartile 2	14.5	18
Quartile 3	18.75	20

Table 2 shows that the control group's post-test dependent variable values (M = 15, SD = 4.63) are lower than those of the experimental group (M = 17.93, SD = 2.79). The p-value for the Levene test of equality of variance is 0.003, which is less than the significance

level of 5%. Consequently, a t-test for independent samples revealed that the difference between the control group and the experimental group post-test with regard to the dependent variable was statistically significant (Cohen, 1988), indicating that there is significant variance equality in the groups: t (47.61) = -2.97, p = 0.005, 95% confidence interval [-4.92, -0.95]. Thus, the null hypothesis 1 (H_{01}) that stated that *"There is no significant difference in the development of number sense between the test scores of learners taught using a multimodal approach and those taught using the traditional approach.*" is rejected.

Table 3: Independent t-test summary of follow-up assessment comparison for control and experimental groups.

	Control Group follow up Assessment	Experimental Group Follow up Assessment
Mean	14.1	16.87
SD	4.26	3.39
Variance	18.16	11.5
Min	6	12
Max	23	24
Q1	11	14
Q2	13.5	17
Q3	17	19

Table 3 demonstrates that the Experimental Group Follow up assessment group (M = 16.87, SD = 3.39) has higher values for the dependent variable than the Control Group follow up assessment group (M = 14.1, SD = 4.26). The difference between the follow-up assessments for the control group and experimental group with regard to the dependent variable (scores) was statistically significant, according to a t-test for independent samples (equal variances assumed): t (58) = -2.78, p = 0.007, 95% confidence interval [-4.76, -

0.78]. Thus, the null hypothesis 2 (H_{02}) that stated that "*There is no significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach.*" is rejected.

Table 4: Shows the descriptive statistics for pre-test and post-test for both groups (Experimental and control)

	No.	Mean	SD	
Experimental Group pre test	30	12.47	2.69	
Experimental Group Post-Test	30	17.93	2.79	
Control Group Pre-Test	30	12.57	3.53	
Control Group Post-Test	30	15	4.63	

The experimental group improved by 5.46 points, compared to the control group's 2.43 point improvement, according to the statistics in the above table. More than twice as much progress was made by the experimental group as by the control group. The experimental group performed more consistently, as indicated by the smaller standard deviation in their post-test, indicating that the majority of learners benefited from the multimodal approach. The control group's higher standard deviation, on the other hand, suggested that learners' progress was less steady. The multimodal approach was significantly more effective in improving learners' performance than the traditional approach, as the experimental group (multimodal approach) showed greater improvements (+5.46 points) than the control group (+2.43 points). *Table 4* demonstrates that the experimental group's performance was better than that of the control group as a result of the multimodal approach. This confirms that the multimodal approach significantly enhances learners' performance compared to traditional teaching methods.

Table 5: Paired t-test summary for the experimental group's pre-test and post-tests.

	Experimental Group pre-test	Experimental Group post test
Mean	12.47	17.93
Std. Deviation	2.69	2.79
Variance	7.22	7.79
Minimum	8	14
Maximum	16	24
Quartile 1	10	16
Quartile 2	12.5	18
Quartile 3	15	20

According to *Table 5*, the experimental group post-test group had higher values (M = 17.93, SD = 2.79) than the Experimental Group Pre-test group (M = 12.47, SD = 2.69). This implies that learners' number concept abilities improved, demonstrating the impact of a multimodal approach on learners' number sense development.

The statistical significance of this difference was demonstrated by a t-test for paired samples: t confidence (29) = -8.13, p = < 0.001, 95% confidence interval [-6.84, -4.09]. As a result, the p-value is less than 0.001, which is below the 0.05 significance level (Cohen, 1988).

Table 6: ANOVA examining effects of traditional instructional approach between the three assessments.

	Control group Pre-Test	Control Group Post-Test	Control Group follow up Assessment
Mean	12.57	15	14.1
std. Deviation	3.53	4.63	4.26
Variance	12.46	21.45	18.16
Min	5	7	6
Max	20	26	23
Q1	10.25	12	11
Q2	12	14.5	13.5
Q3	14.75	18.75	17

Table 6 indicates that when comparing the control group's mean test scores to those of the experimental group, there was a small but not statistically significant difference. The test results for the control group at each of the three evaluation points show a modest increase in mean scores over time. The mean increased from 12.57 (pre-test) to 15.00 (post-test) before slightly decreasing to 14.10 (follow-up assessment). The standard deviation also fluctuated, suggesting variability in individual performance. This proves alternative Hypothesis 1 (H_{11}) that stated that "*There is a significant difference in the development of number sense between test scores of learners taught using a multimodal approach and those taught using a traditional approach*" and alternative Hypothesis 2 (H_{12}) that stated that "*There is a significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."*

Table 7: ANOVA examining the effects of multimodal instructional approach on the three assessments

	Experimental Group Pre-Test	Experimental Group Post-Test	Experimental Group Follow up Assessment
Mean	12.47	17.93	16.87
Std. Deviation	2.69	2.79	3.39
Variance	7.22	7.79	11.5
Min	8	14	12
Max	16	24	24
Q1	10	16	14
Q2	12.5	18	17
Q3	15	20	19

Table 7 demonstrated that the variables differed significantly ($F = 31.7$, $p = < 0.001$). In comparison to the control group in Table 6, the p-value (< 0.001) is significantly below

the significance level of 0.05, suggesting a highly significant difference between the variables. There are significant differences between the groups, as indicated by the strong effect suggested by the F-value of 31.7. The treatment or intervention had a significant effect on the dependent variable, as indicated by the significant F-value and p-value.

Therefore, the null hypothesis 1 (H_{01}) that stated that *" There is no significant difference in the development of number sense between the test scores of learners taught using a multimodal approach and those taught using the traditional approach"* and the other null hypothesis 2 (H_{02}) that stated that "*There is no significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach"* were both rejected, confirming that there are significant differences between the variables. In contrast, this proves the alternative Hypothesis 1 (H_{11}) that stated that *"There is a significant difference in the development of number sense between test scores of learners taught using a multimodal approach and those taught using a traditional approach"* and alternative Hypothesis 2 (H_{12}) that stated that *"There is a significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."*

The experimental group demonstrated a great improvement in mean test scores, increasing from 12.47 (pre-test) to 17.93 (post-test), a mean difference of 5.46 points, before slightly decreasing to 16.87 (follow-up assessment) (an increase of 4.40 points from the pre-test). In contrast, the control group showed a smaller increase from 12.57 (pre-test) to 15.00 (post-test), a mean difference of 2.43 points, before dropping to 14.10 (follow-up assessment) (an increase of only 1.53 points from the pre-test).

These results suggest that the group that received an intervention (experimental) not only achieved a higher immediate improvement from pre- and post-test but also retained more of their gains in the follow-up assessment, indicating a more effective intervention.

4.3 Discussion of findings

This study's results are examined in this section in relation to the research questions and hypotheses. The results were analysed within the context of the theoretical framework and previous research on multimodal teaching approaches and number sense development. The discussion looks at the implications of the findings, highlighting the strengths and limitations of the multimodal approach in enhancing learners' number sense. Furthermore, the findings were compared with existing literature to make meaningful conclusions about the effects of the approach in Mathematics education. This section also addresses potential areas for further research and suggests practical recommendations for educators and policymakers.

4.3.1 Analysis of Research Question 1

"What is the effect of a multimodal approach on the development of number sense in Grade 8 learners?"

Null Hypothesis 1 (H_{01}): *"There is no significant difference in the development of number sense between the test scores of learners taught using a multimodal approach and those taught using the traditional approach."*

Alternative Hypothesis 1 (H_{11}): *"There is a significant difference in the development of number sense between the test scores of learners taught using a multimodal approach and those taught using a traditional approach."*

Following the intervention, the experimental group's number sense abilities significantly improved, according to the paired t-test results in *Table 5*. The multimodal teaching strategy clearly improved learners' number sense, as evidenced by the rise in mean scores from 12.47 on the pre-test to 17.93 on the post-test. This increase suggests that the multimodal approach provided diverse and effective means for learners to engage with and understand number concepts, enhancing their ability to make accurate numerical approximations. This increase suggests that the multimodal approach provided diverse and effective means for learners to engage with and understand number concepts, enhancing their ability to make accurate numerical approximations. This finding aligns with existing literature, which shows that combining visual, auditory, and kinaesthetic strategies supports deeper mathematical understanding and improves number sense by catering to varied learning styles.

The significance of the p-value ($p < 0.001$) shows that the likelihood of observing this improvement due to random variation is extremely low. This strengthens the validity of the observed effect, supporting the alternative hypothesis that the multimodal approach effectively contributes to number sense skill development. Furthermore, a consistent improvement among participants is suggested by the 95% confidence interval for the mean difference, which ranges from -6.84 to -4.09. This further confirms that the multimodal approach had a significant and reliable effect on learner outcomes.

Rejecting the null hypothesis 1 (H_{01}) which stated that *"There is no significant difference on the development of number sense between the test scores of learners taught using a multimodal approach and those taught using the traditional approach,"* while proving the alternative hypothesis 1 (H_{11}) that *"There is a significant difference on the development*

of number sense between the test scores of learners taught using a multimodal approach and those taught using the traditional approach." This implies that traditional instructional approaches might be less effective than multimodal strategies in this context. These results suggest that a multimodal approach, integrating visual, auditory, and kinaesthetic learning methods, can accommodate diverse learner needs, facilitating a deeper understanding of number sense. The findings thus align with research advocating for multimodal approaches in education, as they can support diverse cognitive processes and learning styles, ultimately fostering more comprehensive and retained knowledge in learners (Mayer, 2009; Lee & Kalyuga, 2015). This reinforces the relevance and effect of the multimodal instructional approach used in this study, demonstrating its potential to enhance number sense development among Grade 8 learners in the Namibian context.

In summary, the experimental group showed a slight increase in test performance than the control group results indicate the potential of multimodal teaching strategies to significantly enhance mathematical skills and suggest a valuable direction for future instructional approaches in Mathematics education. Further research may explore additional aspects of number sense or examine the effect on different learner populations to validate and expand on these positive outcomes.

4.3.2 Analysis of null research Hypothesis 1 (H_{01})

Null Hypothesis 1 (H_{01}): *"There is no significant difference in the development of number sense between learners taught using a multimodal approach and those taught using the traditional approach.*"

From *Table 5*, Experimental Group Pre-Test: Mean is 12.47, Standard Deviation is 2.69, and Experimental Group Post-Test: mean is 17.93 and standard deviation is 2.69. The experimental group's post-test scores considerably exceeded their pre-test scores, according to the paired t-test results. The multimodal approach appears to have successfully enhanced learners' number sense abilities, as evidenced by the mean score rising from 12.47 to 17.93. The observed difference is statistically significant, as indicated by the p-value (< 0.001), which is significantly below the significance level of 0.05. Therefore, the null hypothesis (H_{01}) is rejected, suggesting that the multimodal instructional method was associated with higher number sense performance compared to the traditional approach.

On the other hand, the findings, as indicated from *Table 2*, the independent t-test, demonstrate a meaningful effect of the instructional approach on learners' post-test performance. The multimodal approach resulted in a greater development of number sense, as evidenced by the experimental group's significantly higher mean score when compared to the control group. This effect is particularly notable given the unequal variances between groups, as indicated by the significant Levene's test result ($p = 0.003$) (Cohen, 1988). The p-value of 0.005 for the t-test stresses that the difference in post test results is statistically significant. This significant difference suggests that learners exposed to the multimodal instructional approach outperformed those who were in the control group (Cohen, 1988). The confidence interval of [-4.92, -0.95] further reinforces this finding, as it captures the range of likely differences between the groups, consistently showing that the experimental group scored higher post test results. In summary, the results emphasise the effects of a multimodal instructional approach in fostering number

sense development, as they enable a more engaging and effective learning experience. This finding aligns with existing research supporting multimodal approaches, highlighting their capacity to cater to varied learning needs and promote improved retention and understanding of mathematical concepts (Mayer, 2009; Lee & Kalyuga, 2015).

4.3.4 Analysis of research Question 2

"How does the multimodal approach affect the retention of numerical concepts in Grade 8 learners?"

Null Hypothesis 2 (H_{02}): *"There is no significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."*

Alternative Hypothesis 2 (H_{12}): "*There is a significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."*

These findings from *Table 3* suggest that the multimodal instructional approach not only facilitated immediate gains in learners' number concept skills but also had lasting effects, as evidenced by the continued improvement in the follow-up assessment. This finding emphasises the benefits of employing multimodal approaches in the classroom since they seem to promote both long-term retention and application of mathematical concepts in addition to short-term gains. Additionally, the lack of significant variance differences further supports the robustness of the intervention across both groups, further emphasising the reliability of the observed effect.

Thus, the follow-up assessment results provide compelling evidence that the multimodal approach sustained a positive effect on number sense development. These findings align with an increasing body of research suggesting that multimodal strategies enhance both short-term learning outcomes and long-term retention of mathematical skills (Ndinelago, 2021; Potgieter, 2015).

4.3.5 Analysis of null research Hypothesis 2 (H_{02})

Null Hypothesis 2 (H_{02}): *"There is no significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."*

From *Table 3*, Control Group Follow-Up Assessment: Mean is 14.1, Standard Deviation is 4.26, Experimental Group Follow-Up Assessment: Mean is 16.87, Standard Deviation is 3.39. The results of the independent samples t-test show that the experimental group's and the control group's follow-up assessment scores differed significantly.

The experimental group's mean score (16.87) is higher than the control group's (14.1), indicating that the multimodal approach helps learners remember numerical concepts better. The observed difference is statistically significant since the p-value (0.007) is less than the significance level of 0.05. Therefore, the null hypothesis (H_{02}) is rejected, indicating a significant difference in retention between the two groups. In the context of this study, this suggests that the multimodal instructional approach was more effective than the traditional method in supporting learners' long-term retention of number sense concepts.

An analysis of variance using one factor and repeated measures, as presented in Table 6, revealed a significant difference between the variables ($F = 3.27$, $p = 0.045$). Cohen (1988) states that the effect size has three limits: 0.01 for small effects, 0.06 for medium effects, and 0.14 for large effects. Given that the p-value (0.045) is less than the significance level of 0.05, the variables are statistically different. The variables do not all have the same mean, confirming that there are significant differences between the variables being compared.

The results from *Table 7* indicate that the one-factor repeated measures ANOVA yielded a significant F-value ($F = 31.7$, $p < 0.001$), suggesting that the multimodal approach had a strong influence on the measured outcome across the repeated assessments. This high F-value highlights a substantial difference between groups over time, further suggesting that the multimodal instructional approach was effective in enhancing learners' number sense. Given the p-value is well below the 0.05 threshold, the outcomes strongly support that the differences observed are statistically significant.

The repeated measures approach used in this analysis provides insights not only into whether the intervention had an effect but also into how learners' skills changed over time. This approach allows to track changes in each learner's performance across the three assessments. The significant F-value supports those learners in the interventions group consistently demonstrated enhanced performance as compared to the group that received the traditional approach over these assessment points, reinforcing the lasting effect of the multimodal instructional approach.

The results indicate that the multimodal approach did more than just produce a temporary improvement; it facilitated sustained learning and retention of key mathematical concepts

as measured by the follow up assessment/delayed post-test. The substantial F-value and highly significant p-value suggest that the instructional methods employed addressed various learning preferences, potentially leading to deeper cognitive engagement and understanding. This is consistent with educational research advocating for multimodal approaches to support diverse learning styles, which can yield more comprehensive and retained learning outcomes (Potgieter, 2015).

In summary, the significant F-value and p-value together confirm the effects of the multimodal intervention, demonstrating that it had a significant impact on how number sense developed over time. This aligns with the hypothesis that a multimodal instructional approach leads to enhanced mathematical understanding and retention, positioning it as a valuable teaching approach in educational settings focused on long-term learning outcomes.

4.3.6 Comparison of control and experimental groups

The experimental group and control group were compared using the performance mean and standard deviation of the post-test and follow-up assessments. These statistical measures were derived from t-tests and ANOVA to assess the effects of a multimodal instructional approach on developing number sense in Grade 8 learners.

Table 8: *Shows comparison of post-test mean and standard deviation of control and experimental groups*

	Mean	Standard Deviation
Control group	15	4.63
Experimental group	17.93	2.79

From *Table 8*, it shows that a t-test for independent samples with equal variances indicated differs significantly between the two groups, such that t (47.61) = -2.97, p = 0.005, and 95% confidence interval: [-4.92, -0.95]

The data above shows, the experimental group outperformed the control group in the post-test by a significant margin, leading to the rejection of null hypothesis 1 (H_{01}) which stated that *"There is no significant difference in the development of number sense between the test scores of learners taught using a multimodal approach and those taught using the traditional approach."* As can be seen in *Table 4*, there is a noticeable difference in performance between the experimental and control groups on the post-test. The experimental group's mean score (M = 17.93) was higher than the control group's (M = 15), suggesting that learners in the experimental group performed better overall. Furthermore, the standard deviation was lower for the experimental group (SD = 2.79) than for the control group (SD = 4.63), indicating that the experimental group's scores were more tightly clustered around the mean, indicating less variability in performance among participants. On the other hand, the control group's higher standard deviation suggests a wider range of performance levels.

The t-test results for independent samples (t (47.61) = -2.97, p = 0.005) show that there is a statistically significant difference in post-test scores between the two groups, with a p-value well below the 0.05 significance level. This is further supported by the 95% confidence interval for the mean difference [-4.92, -0.95], which offers more proof that the experimental group's scores were actually higher than the control group. The variability in mean scores among the control and experimental groups, combined with the smaller difference in the experimental group, suggests that the multimodal instructional

approach used with the experimental group was effective in enhancing learners' understanding and retention of number sense skills. This supports the hypothesis (H_{11}) that a multimodal approach leads to higher performance and more consistent learning outcomes, as seen in the experimental group's tighter clustering of scores.

Thus, the data from *Table 8* indicates that the experimental group, which received the multimodal instruction, not only performed better on average but also showed more consistent outcomes. This reinforces the effects of the multimodal approach in developing number sense among learners.

Table 9: *Shows the comparison of follow-up assessment between the two groups*

	Mean	Standard deviation
Control group	14.1	4.26
Experimental group	16.87	3.39

Table 9 above indicates that a t-test for independent samples with equal variances also indicated a statistically significant difference between the two groups, such that t (58) = -2.78, p = 0.007, and 95% Confidence Interval: [-4.76, -0.78]

Interpreted, the above data implies that the experimental group continued to outperform the control group in the follow-up assessment, again leading to the rejection of the null hypothesis 2 (H_{02}) which indicated that *"There is no significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."* The follow-up assessment results, as shown in *Table 2*, provide a comparison of the performance of the groups after four weeks of the intervention. The group that received the multimodal approach maintained a higher mean

score (M = 16.87) compared to the group that received the traditional approach (M = 14.1), indicating that learners who received the multimodal intervention continued to outperform those who received traditional instruction. This suggests that the intervention had a lasting effect on learners' number sense skills as indicated in *Table 7* under follow up assessment. Furthermore, there was less variation in the experimental group's scores, as indicated by the lower standard deviation (SD = 3.39) compared to the control group (SD = 4.26). This reduced variability suggests that learners in the experimental group perform more consistently. The results of the independent t-test ($t(58) = -2.78$, $p = 0.007$), there is a statistically significant difference in the follow-up assessment scores between the two groups. Given the p-value of 0.007, which is significantly below the significance level of 0.05, it is unlikely that the observed performance difference is the result of chance. The 95% confidence interval for the difference in mean scores [-4.76, -0.78] reinforces this finding, confirming the significance of the difference. The significant difference in the follow-up assessment mean score reinforced the effects of the multimodal approach in producing long-term gains in number sense skills for learners in the experimental group. The higher mean and lower standard deviation for the experimental group suggest that this group not only retained the skills acquired from the intervention but also performed more consistently than the control group, which had higher variability.

Figure 1: Shows the box and whisker plot summarising the experimental data set of test scores across different assessments.

Figure 1 shows that experimental group consistently shows slightly higher median scores and less variability, indicating the effects of the multimodal teaching approach compared to the traditional approach group.

In summary, the follow-up assessment scores show that the experimental group sustained its improved performance over time, suggesting the long-lasting benefits of the multimodal instructional approach. The boxplot shows that the experimental group's scores improved from the pre-test to the post-test and remained relatively high and stable in the follow-up assessment, with the median increasing and the interquartile range narrowing slightly, indicating consistent performance. In contrast, the control group's scores show a smaller gain and wider spread, especially in the follow-up assessment, where the variability increases. These patterns suggest that the multimodal intervention

not only led to higher average performance but also more stable retention of number sense concepts over time.

Thus, in both the post-test and follow-up assessment, the intervention group indicated a significantly higher performance compared to the traditional group. This suggests that the multimodal approach was effective in developing number sense in grade 8 learners.

4.3.7 Multimodal approach intervention on developing number sense skills

Based on the research results as outlined above, the multimodal approach significantly had a positive effect on the development of the number concept for the Grade 8 learners. *Table 7* presents an ANOVA with repeated measures, showing a significant difference among the variables, with an F-value of 31.7 and a p-value of less than 0.001. This p-value indicates a highly significant difference between the groups because it is significantly lower than the significance level of 0.05. The high F-value of 31.7 suggests a strong effect, meaning the differences observed between the groups are significant.

The significant F-value and corresponding p-value indicate that there were statistically significant differences in learners' performance across the assessment points. This suggests that the instructional method used may have influenced the development of number sense among the groups. While the results point toward a possible effect of the multimodal approach, these findings must be interpreted in light of the study's design and context, acknowledging that other factors may also have contributed to the observed differences.

The significant effect of the multimodal approach on developing number sense skills, as evidenced by the F-value of 31.7 and p-value of less than 0.001, aligns with existing

literature on multimodal learning strategies. Previous studies have highlighted the benefits of incorporating multiple sensory modalities in instruction to enhance cognitive processing and retention. For instance, Boonen et al. (2014) found that learners who engaged with multimodal instructional strategies particularly those involving visual spatial representations demonstrated significantly better performance in solving mathematical problems than peers taught using traditional methods. Similarly, Ndinelago (2021), in a Namibian study on the use of the abacus with Grade 3 learners, reported that multimodal tools supported learners' conceptual understanding of numerical relationships, improving their accuracy and confidence in mathematical tasks. This study shows that multimodal approaches significantly boost engagement and learning outcomes in Mathematics education by engaging multiple senses that build stronger connections, thereby facilitating deeper understanding and retention of mathematical concepts.

The rejection of the null hypothesis in this study and the significant impact of the multimodal approach on developing number sense skills, as evidenced by the F-value of 31.7 and p-value of less than 0.001, align with the principles of logical constructivism. According to this educational theory, learners actively participate in creating their own understanding by interacting with a variety of experiences and stimuli (Brouwer, 1907; Piaget, 1970). Theory of logical constructivism ascertains that , knowledge is created through logical reasoning and engaging with content (Brouwer, 1907).

The multimodal approach, which incorporates visual, auditory, and kinaesthetic elements, provides diverse stimuli that facilitate deeper cognitive processing and understanding. This aligns with this study’s theoretical framework of Brouwer (1907) and Piaget (1970), who argued that learners build knowledge through active exploration and logical

structuring of information. Thus, the statistical evidence from this study not only demonstrates the effects of the multimodal approach in enhancing number sense skills but also reinforces the findings of previous research (Ndinelago, 2021; Potgieter, 2015; Boonen et al., 2014). This alignment with existing literature underscores the potential of multimodal instructional strategies to significantly improve number sense skills in Mathematics.

4.4 Educational Implications of the Findings

Although this study was limited to two schools within the Ncamagoro Circuit in the Kavango West Region, its findings offer meaningful insights for Mathematics education in similar contexts. The results suggest that the use of a multimodal teaching approach integrating visual, auditory, kinaesthetic, and tactile elements, positively influenced Grade 8 learners' development of number sense. The implications of these findings can be considered by educators, school leaders, teacher training institutions, and curriculum developers, particularly within resource-constrained, underperforming schools and/or schools similar to the two selected schools involved for this study.

4.4.1 Implications for Teaching Practices

This study reinforces the value of moving beyond traditional teacher-centred approaches, which often rely on rote learning and procedural instruction. Teachers should be encouraged and supported to implement multimodal strategies, which allow learners to engage with mathematical content through different sensory channels. This can promote better understanding and retention of abstract number concepts. For example, incorporating manipulatives, diagrams, peer discussions, and real-life examples can make number sense more accessible to learners who struggle with traditional instruction.

4.4.2 Implications for Teacher Professional Development

The findings highlight the need for continuous professional development that equips Mathematics teachers with the knowledge and skills to design and deliver multimodal lessons. Training workshops and in-service programs should emphasize learner-centred teaching, the use of low-cost teaching aids, and the pedagogical benefits of multimodal instruction. Teacher training institutions may also consider integrating these methods into their coursework to better prepare pre-service teachers for diverse classroom environments.

4.4.3 Implications for Curriculum Design and Materials

Curriculum developers may use these findings to consider incorporating explicit guidelines for multimodal instruction in topics related to number sense, such as estimation, operations, and number relationships. Teaching materials and textbooks could be redesigned to include activities that support various learning styles, visual, auditory, and kinaesthetic, especially for foundational Mathematics topics.

4.4.4 Implications for Resource Provision in Rural Schools

The positive results from a multimodal approach point to the importance of equipping schools with basic, affordable learning materials such as number lines, counters, place value charts, and visual models. Education stakeholders and policymakers should consider how to support rural schools with such resources, even if they are improvised or low-cost, to facilitate multimodal instruction.

4.4.5 Implications for Further Research

While the results are promising, they are limited to a small sample within one circuit. Future research could extend this work by applying the multimodal approach across multiple regions and grade levels, including longitudinal studies to assess long-term effects on learners' mathematical development. Findings from such broader studies could support evidence-based policy recommendations at the national level.

4.5 Chapter 4 summary

Chapter 4 presented and discussed this study's findings on the effects of a multimodal approach in developing number sense among Grade 8 learners at the two selected schools in Ncamagoro circuit. The first section, Presentation of Results, provided descriptive statistics, t-tests, and ANOVA results. The results revealed a significant improvement in the experimental group's performance from pre-test to post-test, with independent t-tests confirming that the experimental group outperformed the control group in both post-test and follow-up assessments. Box-and-whisker plots in *Figure 1* illustrated the data distribution, reinforcing the effects of the multimodal approach.

The second section, Discussion of this study Findings, analysed the results under specific themes. The descriptive analysis of the five-point summary, group means, standard deviation, and variance confirmed the superior performance of the experimental group. The findings further highlighted the effects of the multimodal approach in enhancing number sense, as the integration of visual, auditory, and kinaesthetic elements improved learners' understanding and retention of mathematical concepts. Finally, the discussion explored the educational implications, emphasizing on the value of multimodal strategies in supporting number sense, the need for teacher training on using diverse instructional

methods, the importance of resources and materials to support visual and tactile learning and how curriculum developers might consider including multimodal practices in number sense topics. The overall results support the use of multimodal teaching methods as a valuable approach to improving Mathematics education in similar educational setting such as those for the two selected schools in Ncamagoro circuit.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This Chapter provides this study's summary, conclusions, and recommendations based on the findings and discussions of the results. This study sought to determine whether the multimodal teaching approach had any impact on the number sense development of Grade 8 learners in the Kavango West Region's Ncamagoro circuit. This sought answers to the following questions and hypotheses:

Question 1: *"What are the effects of a multimodal approach on the development of number sense in Grade 8 learners?"*

Null Hypothesis 1 (H_{01}): *"There is no significant difference in the development of number sense between learners taught using a multimodal approach and those taught using the traditional approach."*

Alternative Hypothesis 1 (H_{11}): *"There is a significant difference in the development of number sense between learners taught using a multimodal approach and those taught using a traditional approach."*

Question 2: *"How does the multimodal approach affect Grade 8 learners' retention of numerical concepts?"*

Null Hypothesis 2 (H_{02}): *"There is no significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."*

Alternative Hypothesis 2 (H_{12}): *"There is a significant difference in the retention of numerical concepts between learners taught using the multimodal approach and those taught using the traditional approach."*

5.2 Summary

This study investigated the effects of a multimodal teaching approach on the development of number sense among Grade 8 learners at two secondary schools in the Ncamagoro Circuit, Kavango West Region, Namibia. A quasi-experimental design with pre-test, post-test, and follow-up assessments was employed, involving two groups: an experimental group that received multimodal instruction and a control group that was taught using traditional methods. This study used total population sampling, including all 60 Grade 8 learners (30 from each school).

Quantitative data were collected through structured tests and analysed using descriptive statistics, independent t-tests, and one-way repeated measures ANOVA to assess differences in performance over time. The results indicated that the experimental group showed statistically significant improvement in number sense development, both immediately after the intervention and in the follow-up assessment, compared to the control group.

This study's findings resonate with existing research in the field, which has shown that a multimodal instructional approach incorporating visual, auditory, and kinaesthetic elements can significantly improve learners' number sense and enhance learning outcomes in Mathematics. For instance, local studies by Ndinelago (2021) and Potgieter (2015) demonstrated that the use of tactile and visual tools such as the abacus and manipulatives supported conceptual understanding and improved number-related skills

among lower primary learners in Namibia. Internationally, Boonen et al. (2014) found that visual–spatial strategies contributed to better performance in solving mathematical word problems. These findings align with Piaget's (1970) constructivist theory, which posits that learners build knowledge actively through sensory interaction and exploration of their environment. The results are further supported by Lee and Kalyuga (2015), who showed that well-integrated multimodal instruction reduces cognitive load and improves both immediate learning outcomes and long-term retention in mathematical tasks.

Through a quasi-experimental method, this study demonstrated that learners in the group who received multimodal instruction significantly differed and outperformed those in the group who received the traditional approach. The post test scores for the experimental group ($M = 17.93$, $SD = 2.79$) were notably higher than those of the control group ($M = 15.00$, $SD = 4.63$), confirming the effectiveness of multimodal teaching in fostering immediate understanding of number sense concepts. Moreover, follow-up assessment activities conducted four weeks after the intervention indicated that the experimental group retained and displayed a higher level of number concepts ($M = 16.87$, $SD = 3.39$) compared to the control group ($M = 14.1$, $SD = 4.26$).

This study's findings not only highlight the benefits of the multimodal instructional approach but also advocate for its widespread adoption in educational settings contexts similar to the one in this study. Building on the literature that emphasises the importance of inclusive and adaptive teaching methods (Ministry of Education, Arts, and Culture, 2007), the chapter concludes with specific recommendations for promoting the integration of multimodal teaching strategies in Namibia's education system. The recommendations focused on curriculum reforms, professional development for teachers, and the provision

of resources, all of which are essential for maximising the benefits of multimodal instruction for learners across diverse contexts.

5.3 Conclusions

This study aimed to assess the impact of a multimodal teaching strategy on improving Grade 8 learners' number sense development. Focusing on numerical relationships, this study aimed to address whether multimodal methods could overcome limitations associated with traditional teaching approaches in Mathematics. In order to measure the immediate and long-term effects of the multimodal instructional approach, this study compared the experimental and control groups' pre-test, post-test, and follow-up assessments.

This study's findings showed that the intervention, multimodal approach enhanced learners' development of number sense as revealed by statistical analyses, including ANOVA and t-tests, showing differences in performance, indicating that the intervention was effective. The differences in performance support the argument that incorporating multiple modes of representation enhances mathematical understanding, reinforcing the importance of diverse teaching strategies in Mathematics education. This study effectively addresses the research objectives, showing that the problem of developing number sense in Grade 8 learners was successfully tackled through a multimodal instructional approach. This study’s results align with a theory of learning rooted in the ideas of L.E.J. Brouwer, influenced by the cognitive development theory of Jean Piaget, which emphasises that knowledge is actively constructed by learners through logical thinking and meaningful experiences. Logical constructivism theory is more suited for Mathematics education, particularly number sense, as it integrates logic with sensory

learning experiences (Brouwer, 1907; Piaget, 1971). The intervention, multimodal approach significantly enhanced learners' numerical relationship skills, as well as their retention of mathematical concepts. The findings reveal that a multimodal approach can improve learners' understanding of number sense more effectively than traditional teaching methods.

Through this study, it became evident that integrating visual, auditory, and kinaesthetic modalities provides a more engaging and effective learning experience, catering to diverse cognitive needs and helping learners internalise concepts. This multimodal approach was particularly beneficial in maintaining learners' attention, boosting their performance after the intervention, and sustaining improvement in the follow-up assessment. While the current study demonstrated effectiveness with number sense (on the estimation topic) in a controlled setting, further research could examine whether these findings hold across other mathematical concepts, and in broader, diverse educational environments.

The sample was limited to Grade 8 learners from two selected schools in Ncamagoro circuit, which may limit the generalisability of the findings to other grades or regions. Additionally, the practical implementation of a multimodal approach may face logistical challenges, particularly in schools with limited resources for diverse instructional materials. Despite these limitations, this study's strengths lie in its clear demonstration of the benefits of a multimodal approach, with statistically significant results that align with theoretical principles of constructivism and prior research.

The potential applications of this study are significant. By incorporating multimodal strategies into Mathematics curricula, educators can foster deeper understanding and retention of mathematical concepts. This approach is especially relevant for teacher

training and curriculum design, where understanding learners' varied sensory needs can enhance instructional effectiveness. Additionally, policymakers could leverage these findings to advocate for resources and support to implement multimodal learning across schools, improving overall educational outcomes in Mathematics and potentially other subjects.

The following key findings were observed such as, multimodal teaching significantly enhanced number sense as learners taught through visual, auditory, and kinaesthetic methods demonstrated improved performance in estimation, numerical relationships, and mental arithmetic; Sustained learning was observed as the follow-up assessment showed that number sense improvements made through the multimodal approach were retained over time; Traditional teaching methods remain less effective as, the control group, which received traditional instruction, showed minimal improvement in number sense development. Therefore, findings are consistent with previous studies and aligns with literature such as Ndinelago (2021), Potgieter (2015), and Mayer (2009), which advocate for learner-centred, multimodal strategies to support mathematical understanding.

In conclusion, the use of multimodal instructional strategies has showed a positive and lasting impact on the development of number sense in the learners from the two selected schools and presents a practical alternative to traditional methods in similar educational contexts.

5.4 Recommendations

While the findings of this study are context-specific and not generalisable beyond the two participating schools in the Ncamagoro Circuit, they nonetheless provide valuable insights into the role of multimodal instructional strategies in improving number sense

among Grade 8 learners. The use of a total population sample within a limited setting means that the recommendations should be considered with caution and applied primarily to similar rural educational contexts. However, the consistent improvement observed in the experimental group suggests that multimodal teaching holds promise as a practical and effective pedagogical approach. Based on these findings, the following recommendations are proposed for educators, school leaders, curriculum developers, and researchers.

5.4.1 For Teachers

- Incorporate multimodal teaching strategies in Mathematics lessons to address diverse learning styles.
- Use low-cost or improvised visual and tactile materials (e.g., counters, diagrams, number lines) to reinforce number concepts.
- Engage learners in interactive and exploratory activities to foster deeper understanding.

5.4.2 For School Leaders and Educational Planners

- Provide professional development opportunities for teachers to learn and implement multimodal teaching techniques.
- Ensure that rural schools are equipped with basic teaching aids that support varied instructional modes.

5.4.3 For Curriculum Developers

- Integrate multimodal teaching guidance into the national Mathematics curriculum, particularly in the teaching of number sense.
- Encourage the inclusion of practical, real-life tasks that engage multiple senses and promote active problem-solving.

5.4.4 For Further Research

- Replicate this study in other regions and grade levels to validate and extend the findings.
- Explore the long-term impact of multimodal instruction on broader mathematical competencies such as algebra and geometry.
- Conduct mixed-methods research to capture learners' and teachers' experiences with multimodal teaching more deeply.

5.5 Chapter 5 summary

This Chapter shows the summary, conclusion, and recommendations of this study. This study determined the effect of multimodal teaching approach on number sense and improvement and retention of numerical concepts compared to traditional teaching methods.

Findings from this quasi-experimental research showed that learners taught using the multimodal approach performed better in both immediate assessments and follow-up evaluations than the traditional group. The experimental group performed better than the control group, according to statistical analyses, indicating the benefits of multimodal

instruction for enhancing number sense and retention. These results align with existing research and constructivist learning theories, reinforcing the value of using visual, auditory, and kinaesthetic teaching strategies. This study provides answers to the two research questions by showing that the multimodal instructional approach greatly enhanced the number sense of the experimental group's learners, as demonstrated by their improved conceptual understanding and higher test scores. The multimodal method led to better retention of mathematical concepts over time, as demonstrated by the experimental group’s follow-up assessments showing sustained learning gains.

This study recommends adopting multimodal instruction in Mathematics classrooms similar to the studied schools in Ncamagoro circuit, providing teacher training on these strategies, integrating them into teacher education programs, and ensuring schools, especially those in rural areas, have adequate resources to implement them. Further research is suggested to explore multimodal approaches across other mathematical topics, different age groups, and broader educational settings. Overall, the findings of this study suggest that multimodal instruction may support both immediate learning and long-term retention of number sense, indicating its potential as a valuable strategy for improving Mathematics instruction in similar educational settings.

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APPENDICES

Appendix 1: Ethical clearance letter from UNAM

ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: RUC00026 **Date: 24/06/2024**

This Ethical Clearance Certificate is issued by the University of Namibia Ethics Committee (REC) in accordance with the University of Namibia's Research Ethics Policy and Guidelines. Ethical approval is given in respect of undertakings contained in the Research Project outlined below. This Certificate is issued on the recommendations of the ethical evaluation done by the ethics committee.

Title of Project: Effects of a multi-modal approach in developing number sense in grade 8 learners in Ncamagoro Circuit, Kavango West Region

Principal researcher: Moses Kahuli

Student number: 201311852

Centre for Research Services

Take note of the following:

1. Any significant changes in the conditions or undertakings outlined in the approved Proposal must be communicated to the ethics committee. An application to make amendments may be necessary.
2. Any breaches of ethical undertakings or practices that have an impact on ethical conduct of the research must be reported to the ethics committee
3. The Principal Researcher must report issues of ethical compliance to the ethics committee (through the Chairperson) at the end of the Project or as may be requested by the ethics committee
4. The ethics committee retains the right to:

i) Withdraw or amend this Ethical Clearance if any unethical practices (as outlined in the Research Ethics Policy) have been detected or suspected.

ii) Request for an ethical compliance report at any point during the course of the research.

The ethics committee wishes you the best in your research.

Dr Emilia N Mbongo (Chairperson: Decentralized Ethics Committee)

Prof. Davis Mumbengegwi (Head, Multidisciplinary Research

Appendix 2: Permission letter from UNAM

CENTRE FOR RESEARCH SERVICES
Office of the Pro-Vice Chancellor: Research, Innovation & Development
University of Namibia, Private Bag 13301, Windhoek, Namibia
340 Mandume Ndemufayo Avenue, Pioneers Park, Office F223 - Palock, Second Floor
☎ +264 61 206 4673; E-mail:dmbulu@unam.na; URL: http://www.unam.edu.na

UNAM
UNIVERSITY OF NAMIBIA

RESEARCH PERMISSION LETTER

Date: 08/07/2024

Student Name: MOSES KAHULI

Student Number: 201311852

Programme: MASTER OF EDUCATION

Approved Research Title: EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

TO WHOM IT MAY CONCERN:

I hereby confirm that the above-mentioned student is registered at the University of Namibia for the programme indicated. The proposed study met all the requirements as stipulated in the University guidelines and has been approved by the relevant committees.

The proposal adheres to ethical principles as per attached Ethical Clearance Certificate. Permission is hereby granted to carry out the research as described in the approved proposal.

Best Regards

Dr. AEE Shikongo
Head: Postgraduate Research Support Services
Tel: +264 61 206 3129
E-mail: aeshikongo@unam.na

CENTRE FOR RESEARCH SERVICES
Office of the Director
2024 -07- 08
University of Namibia
UNAM

Appendix 3: **A pre-test**

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

DATA COLLECTION TOOL

Research Instrument: Numerical Relationships Assessment (Pre-test)

Participant no._____Date: _____Group: _____

This research instrument aims to assess the understanding and proficiency of Grade 8 learners in Ncamagoro Circuit regarding numerical relationships, number sense in particular. The assessment test focuses on three key areas: Estimation, Comparing and Ordering. The test consists of a total of 20 marks and aims to provide valuable insights into learners' mathematical abilities and areas that requires further attention. The names and information will be kept anonymous and not be revealed to a third party. The participant has the right to withdraw from the interview at any time if you are not comfortable and/or if not willing to write the test.

Instructions to learners:

- Write your participant's number and group in the spaces provided at the top of this paper.
- Read each question carefully before attempting to solve it.
- Show all your work and calculations clearly.

- Write your answers in the spaces provided.

Part A: Estimation (10 marks)

a) Write the number 3284.596 correct to:

(i) the nearest hundred Answer_____(1)

(ii) the nearest tenth Answer_____(1)

(iii) two decimal places Answer_____(1)

b) Estimate the sum of the following calculation: 16.7 + 9.8

_____

_____(1)

c) Estimate the product of the following calculation: 2.5 × 3.8 × 4.2

_____

_____(2)

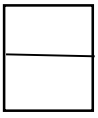
d) Estimate the quotient of the following calculation: 31.2 ÷ 4.9

_____

_____(2)

e) Estimate the value of $\sqrt{41}$ to the nearest whole number.

_____ (2)



Part B: Comparing and Ordering (20 marks)

(a) 0.072; $\frac{72}{100}$; 0.702; $\frac{7}{10}$; $\frac{7}{100}$; $\frac{7.2}{100}$

From the values listed above, write down

(i) The smallest Answer_____ (1)

(ii) The largest Answer_____ (1)

(iii) The two which are equal Answer_____ (2)

(b) Write the following in descending order $\frac{1}{1000}$; $\frac{11}{1000}$; $\frac{0.11}{100}$; 0.0108; 0.1008

_____ (5)

(c) Arrange the following from small to big 50; -22; -13; 1; 14; -45

_____ (6)

(d) Write one of the symbols <, > or = to make the statement true.

(i) 0.667 $\frac{3}{5}$ (1)

(ii) 0.78 $\frac{7}{9}$ (1)

(iii) 3^2 2^3 (1)

(iv) $\frac{9}{100}$ 0.09 (1)

(v) $(0.2)^2$ 0.041 (1)

Thank you for your time!

Appendix 4: A post-test

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

DATA COLLECTION TOOL

Research Instrument: Numerical Relationships Assessment (Post-test)

Participant no._____Date_____Group:_____

This research instrument aims to assess the understanding and proficiency of Grade 8 learners in Ncamagoro Circuit regarding numerical relationships, number sense in particular. The assessment test focuses on three key areas: Estimation, Comparing and Ordering. The test consists of a total of 30 marks and aims to provide valuable insights into learners' mathematical abilities and areas that requires further attention. The names and information will be kept confidential and not be revealed to a third party. The participant has the right to withdraw from the interview at any time if you are not comfortable and/or if not willing to write the test.

Instructions to learners:

- Write your participant's number and group in the spaces provided at the top of this paper.
- Read each question carefully before attempting to solve it.
- Show all your work and calculations clearly.
- Write your answers in the spaces provided.

Part A: Estimation (10 marks)

a) Round each number to the nearest whole number:

(i) 3.72 ≈ _____ (1 mark)

(ii) 6.28 ≈ _____ (1 mark)

b) Estimate the quotient of the following calculation: 2.8 ÷ 0.4

_____

_____(2 marks)

c) Estimate the product of the following calculation: 2.5 × 3.8 × 4.2

_____

_____(2 marks)

d) Estimate the sum of the following calculation: 34.6 + 0.2 + 6.7 + 19.8

_____

_____(2 marks)

e) Estimate the value of $\sqrt{24}$ to the nearest whole number.

_____ (2 marks)

Part B: Comparing and Ordering (20 marks)

(a) 0.072; $\frac{72}{100}$; 0.702; $\frac{7}{10}$; $\frac{7}{100}$; $\frac{7.2}{100}$

From the values listed above, write down

(i) The smallest Answer_____ (1)

(ii) The largest Answer_____ (1)

(iii) The two which are equal Answer_____ (2)

(iv) Write the following in descending order $\frac{1}{1000}$; $\frac{11}{1000}$; $\frac{0.11}{100}$; 0.0108; 0.1008

_____ (5)

(b) Arrange the following from small to big 50; -22; -13; 1; 14; -45

_____ (6)

(c) Write one of the symbols <, > or = to make the statement true.

(i)	0.667	$\frac{3}{5}$	(1)
(ii)	0.78	$\frac{7}{9}$	(1)
(iii)	3^2	2^3	(1)
(iv)	$\frac{9}{100}$	0.09	(1)
(v)	$(0.2)^2$	0.041	(1)

Thank you for your time!

Appendix 5: A follow up assessment

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

DATA COLLECTION TOOL

Assessment: Retention of Numerical Relationships

Name:_____Date_____Grade:_____

This research instrument aims to assess the understanding and proficiency of Grade 8 learners in Ncamagoro Circuit regarding numerical relationships, number sense in particular. The assessment test focuses on three key areas: Estimation, Comparing and Ordering. The test consists of a total of 30 marks and aims to provide valuable insights into learners' mathematical abilities and areas that requires further attention. This assessment is designed to measure the learner's retention of numerical relationships. The names and information will be kept confidential and not be revealed to a third party. The participant has the right to withdraw from the interview at any time if you are not comfortable and/or if not willing to write the test.

Instructions to learners

1. Write your participant's number and group in the spaces provided at the top of this paper.

2. There are 15 multiple-choice questions in total.
3. Choose the most appropriate option for each question and mark your answer by circling.

Topic: Estimation, Comparing and Ordering **(30 Marks)**

(a) Give an estimate of 7856 + 1458 by rounding off each number to the nearest 100.

Answer_____ (2)

(b) Estimate the value of $\sqrt[3]{66} \times \sqrt{52}$. Answer should be correct to 3 decimal places.

Answer_____ (2)

(c) Arrange the following numbers in ascending order.

4.82; 4.79; 4.68; 4.98; 3.99

_____ (5)

(d) Arrange the following numbers in descending order.

$\frac{2}{3}$; $\frac{7}{10}$; 0.67; 0.76; $\frac{3}{4}$

_____ (5)

(e) Use <; > or = to make the statement true

(i) $\frac{37}{73}$……0.507 (1)

(ii) 0.275……$\frac{275}{1000}$ (1)

(iii) 2^3…….3^2 (1)

(iv) -30……30 (1)

(f) A rectangular sign board measures 2.12m by 4.07m.

(i) Find an estimate of its area.

Answer_____ (1)

(ii) Give your answer in (i) correct to two decimal places.

Answer_____ (1)

Thank you for your time!

Appendix 6: Learner information sheet and consent form

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

LEARNER INFORMATION SHEET AND INFORMED CONSENT FORM

This Informed Consent Form has two parts:

• Information Sheet (this section, to share information about this study with you)

• Certificate of Consent (for signatures if you choose to participate)

You will be given a copy of the full Informed Consent Form.

PART I: INFORMATION SHEET

Introduction: I am a Master of Education student from the University of Namibia, conducting a research study on the 'Effects of a multi-modal approach in developing number sense in Grade 8 learners.' I am giving you information and inviting you to be part of this research. Before you decide, you can talk to anyone you feel comfortable with about the research. This consent form may contain words that you do not understand. Please ask me to explain them to you. If you have questions later, feel free to ask further.

Purpose of the Research: Using a multimodal approach to develop number sense in Grade 8 learners, offers a comprehensive way to enhance the understanding of number

concept by incorporating multiple sensory modalities, such as visual representations, manipulative and verbal explanations**.** This study's findings can inform teaching practices, curriculum design, and professional development for Mathematics teachers on the alternative way of developing number sense by looking at the effects of a multimodal approach**.**

Type of Research Intervention: This research will involve your participation in attending a Mathematics session and taking tests, answering questions that will take about 30 minutes.

Participant Selection: You are being invited to participate in this research because we feel that as a learner you can contribute to the best approach to develop number sense to Grade 8 learners in Namibian schools.

Voluntary Participation: Your participation in this research is entirely voluntary. It is your choice whether to participate or not.

Procedures: You will be given test paper to answer; you have to answer the test at school and give it back to the researcher. For the protection of your identity, you are requested not to write your name anywhere on the test script. The scripts will be kept safe and locked in a cabinet. The information on the test scripts is confidential, and no one else except the researcher will have access to it. The raw data will be destroyed one month after completion of this study.

Duration: The test is about 30 minutes long.

Risks: There is no risk involved by taking part in this research. These will be the normal teaching and learning activities which is part of the curriculum. However, you may choose not having your test results form part of the research data.

Benefits: There will be benefit from the Mathematics lessons and your participation will help me find out more about what best approach Mathematics teachers in Namibian schools can use which could also lead to better performance of learners.

Reimbursements: You will not be provided with any payment for taking part in the research.

Confidentiality: Your personal information in the report emanating from this study will be kept confidential; your real name will not appear anywhere in the research report or other publications resulting from this research. You will not be required to write your name on the test paper, but only the assigned number.

Who to Contact: If you have any questions, you can ask them now or later. If you wish to ask questions later, you may contact me on 0818015337 or my supervisor at hmiranda@unam.na

This research has been reviewed and approved by the relevant Ethics Review Committee at the University of Namibia, which is a committee whose task it is to make sure that research participants are protected from harm. The committee reports to the University's Centre for Research Services. If you wish to contact this Centre, please call +264 61 206 4673 or send an e-mail to research@unam.na.

NB: If you agree to take part in this study, please complete the attached consent form and return it to me upon visiting your school.

PART II: CERTIFICATE OF CONSENT (LEARNERS)

I have read the foregoing information, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have been asked have been answered to my satisfaction. I consent voluntarily to be a participant in this study. By signing this consent form, I agree to:

1. Assigned to any group and Participating in the lessons,
2. Taking part in the pre-test, post-test and follow up assessment.

……. ……

Name and Signature of Participant/Parent/Guardian (print)

Date (day/month/year) ……

Statement by the Researcher/Person taking Consent

I have accurately read out the information sheet to the learners as potential participants to this study, and to the best of my ability made sure that the participants understand that the following will be done:

1. Anonymity and voluntary participation will be ensured

2. No risk of physical or emotional harm will be posed to participants.

3. No real names of the participants or their school will be published.

4. Information collected from this study will be treated with confidentiality.

I confirm that the participant was given an opportunity to ask questions about this study, and all the questions asked by the participant have been answered correctly and to the best of my ability. I further confirm that the individual has not been forced into giving consent, and the consent has been given freely and voluntarily.

A copy of this ICF has been provided to the participant.

Appendix 7: Permission letter to ED

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

TO: The Executive Director

Mrs. Sanet Steenkamp

Ministry of Education, Arts and Culture

Private Bag 13186

Windhoek

From: Moses Kahuli

P.O.BOX 848

Rundu

carhuly@gmail.com

SUBJECT: PERMISSION TO CONDUCT A RESEARCH STUDY IN SCHOOLS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

Dear: Mrs. Sanet Steenkamp

I am Moses Kahuli (Student number 201311852), a Masters of Education student (Mathematics Education) at the University of Namibia. I write to kindly request, from your good office, permission to conduct a research study titled "Effects of a multi-modal approach in developing number sense in Grade 8 learners in Ncamagoro circuit, Kavango

West Region." As a researcher for this study, I will be working closely with Grade 8 learners in the Ncamagoro Circuit of Kavango West Region, to investigate effective strategies that can enhance their number concept skills using multimodal teaching approach.

It is against this background that I approach your good office and request permission to allow me access to the schools in the mentioned circuit. From this study, I hope to establish relevant intervention strategies that can inform teaching practices, curriculum design, and professional development for Mathematics teachers.

This study was granted ethical clearance by the UNAM Research Ethics Committee (UREC) and will involve the learners attending Mathematics lessons and writing tests. The research will strictly adhere to ethical guidelines ensuring the anonymity, confidentiality and voluntary participation of all participants. The research study will also adhere to the timetable that is in place at school to ensure that lessons and school activities are not interrupted.

I have attached my research proposal as well as the certificate of ethical clearance issued by the UNAM Research Ethics Committee (UREC)

Thanking you very much in advance for considering my request.

Yours sincerely,

_____ 10 July 2024

Moses Kahuli Date

Appendix 8: Permission letter to RD

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

TO: The Regional Director

Mr. Musore Pontianus

Directorate of Education

Nkurenkuru Regional Office

From: Moses Kahuli

P.O.BOX 848

Rundu

carhuly@gmail.com

SUBJECT: PERMISSION TO CONDUCT A RESEARCH STUDY IN SCHOOLS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

Dear: Mr. Musore Pontianus

I am Moses Kahuli (Student number 201311852), a Masters of Education student (Mathematics Education) at the University of Namibia. I write to kindly request, from your good office, permission to conduct a research study titled "Effects of a multi-modal approach in developing number sense in Grade 8 learners in Ncamagoro circuit, Kavango West Region." As a researcher for This study, I will be working closely with Grade 8

learners in the Ncamagoro Circuit of Kavango West Region, to investigate effective strategies that can enhance their number concept skills using multimodal teaching approach.

It is against this background that I approach your good office and request permission to allow me access to the schools in the mentioned circuit. From this study, I hope to establish relevant intervention strategies that can inform teaching practices, curriculum design, and professional development for Mathematics teachers.

This study was granted ethical clearance by the UNAM Research Ethics Committee (UREC) and will involve the learners attending Mathematics lessons and writing tests. The research will strictly adhere to ethical guidelines ensuring the anonymity, confidentiality and voluntary participation of all participants. The research study will also adhere to the timetable that is in place at school to ensure that lessons and school activities are not interrupted.

A letter of permission from the Executive Director, Ministry of Education, Arts and Culture is attached.

Thanking you very much in advance for considering my request.

Yours sincerely

_____ 15 July 2024

Moses Kahuli Date

Appendix 9: Permission letter to IOE

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

TO: The Inspector of Education

Mr. Veiko Kamukwanyama

Ncamagoro Circuit

Directorate of Education

From: Moses Kahuli

P.O.BOX 848

Rundu

carhuly@gmail.com

SUBJECT: PERMISSION TO CONDUCT A RESEARCH STUDY IN SCHOOLS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

Dear: Mr. Veiko Kamukwayama

I am Moses Kahuli (Student number 201311852), a Masters of Education student (Mathematics Education) at the University of Namibia. I write to kindly request, from your good office, permission to conduct a research study titled "Effects of a multi-modal approach in developing number sense in Grade 8 learners in Ncamagoro circuit, Kavango West Region." As a researcher for This study, I will be working closely with Grade 8

learners in the Ncamagoro Circuit of Kavango West Region, to investigate effective strategies that can enhance their number concept skills using multimodal teaching approach.

It is against this background that I approach your good office and request permission to allow me access to the schools in the mentioned circuit. From this study, I hope to establish relevant intervention strategies that can inform teaching practices, curriculum design, and professional development for Mathematics teachers.

This study was granted ethical clearance by the UNAM Research Ethics Committee (UREC) and will involve the learners attending Mathematics lessons and writing tests. The research will strictly adhere to ethical guidelines ensuring the anonymity, confidentiality and voluntary participation of all participants. The research study will also adhere to the timetable that is in place at school to ensure that lessons and school activities are not interrupted.

A letter of permission from the Regional Director is attached.

Thanking you very much in advance for considering my request.

Yours sincerely

_____ 02 August 2024

Moses Kahuli Date

Appendix 10: Permission letter to the school principal 1

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

TO: The principal

Rio Combined School

Ncamagoro Circuit

From: Moses Kahuli

P.O.BOX 848

Rundu

carhuly@gmail.com

SUBJECT: PERMISSION TO CONDUCT A RESEARCH STUDY IN SCHOOLS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

Dear: Sir/Madam

I am Moses Kahuli (Student number 201311852), a Masters of Education student (Mathematics Education) at the University of Namibia. I write to kindly request, from your good office, permission to conduct a research study titled "Effects of a multi-modal approach in developing number sense in Grade 8 learners in Ncamagoro circuit, Kavango West Region." As a researcher for this study, I will be working closely with Grade 8

learners in the Ncamagoro Circuit of Kavango West Region, to investigate effective strategies that can enhance their number concept skills using multimodal teaching approach.

It is against this background that I approach your good office and request permission to allow me access to the schools in the mentioned circuit. From this study, I hope to establish relevant intervention strategies that can inform teaching practices, curriculum design, and professional development for Mathematics teachers.

This study was granted ethical clearance by the UNAM Research Ethics Committee (UREC) and will involve the learners attending Mathematics lessons and writing tests. The research will strictly adhere to ethical guidelines ensuring the anonymity, confidentiality and voluntary participation of all participants. The research study will also adhere to the timetable that is in place at school to ensure that lessons and school activities are not interrupted.

A letter of permission from the Executive Director, Ministry of Education, Arts and Culture is attached.

Thanking you very much in advance for considering my request.

Yours sincerely

28.08.2024

Moses Kahuli Date

Appendix 11: Permission letter to the school principal 2

EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

TO: The principal

Nally Combined School

Ncamagoro Circuit

From: Moses Kahuli

P.O.BOX 848

Rundu

carhuly@gmail.com

SUBJECT: PERMISSION TO CONDUCT A RESEARCH STUDY IN SCHOOLS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION

Dear: Sir/Madam

I am Moses Kahuli (Student number 201311852), a Masters of Education student (Mathematics Education) at the University of Namibia. I write to kindly request, from your good office, permission to conduct a research study titled "Effects of a multi-modal approach in developing number sense in Grade 8 learners in Ncamagoro circuit, Kavango West Region." As a researcher for this study, I will be working closely with Grade 8

learners in the Ncamagoro Circuit of Kavango West Region, to investigate effective strategies that can enhance their number concept skills using multimodal teaching approach.

It is against this background that I approach your good office and request permission to allow me access to the schools in the mentioned circuit. From this study, I hope to establish relevant intervention strategies that can inform teaching practices, curriculum design, and professional development for Mathematics teachers.

This study was granted ethical clearance by the UNAM Research Ethics Committee (UREC) and will involve the learners attending Mathematics lessons and writing tests. The research will strictly adhere to ethical guidelines ensuring the anonymity, confidentiality and voluntary participation of all participants. The research study will also adhere to the timetable that is in place at school to ensure that lessons and school activities are not interrupted.

A letter of permission from the Executive Director, Ministry of Education, Arts and Culture is attached.

Thanking you very much in advance for considering my request.

Yours sincerely

28.08.2024

Moses Kahuli Date

Appendix 12: Experimental group lesson plans

<table>
<tr><td>Teacher: Mr. Kahuli Moses</td><td>Multimodal Lesson 1
Grade: 8</td><td>Duration: 40 minutes</td></tr>
<tr><td colspan="3">Subject: Mathematics</td></tr>
<tr><td colspan="3">Theme: 1. Numbers</td></tr>
<tr><td colspan="3">Topic: (g) Comparing</td></tr>
<tr><td colspan="3">Teaching Aid: chalk, chalkboard, handouts, projector</td></tr>
<tr><td colspan="3">Lesson Objective: Acquire further knowledge on comparing, ordering and estimation of integers and fractions.</td></tr>
<tr><td colspan="3">Specific Objectives: Use =, < (strictly less than) and > (strictly greater than) to compare integers and/or fractions</td></tr>
<tr><td colspan="3">Lesson Presentation Content</td></tr>
<tr><td>Teacher's Activities</td><td colspan="2">Learner's Activities</td></tr>
<tr><td>Display a few pairs of integers and fractions on the board using flash cards or/and a digital tool, such as a projector.
Ask learners quick comparison questions: e.g., "Which is greater: -3 or 5? 1/4 or 1/2?"
The teacher present examples of comparing integers and fractions on the board.
Explain the rules and strategies for comparing integers and fractions.
Emphasize rules and the use of =, <, and > through guided examples.
Encourage teamwork to apply learning by Spliting the class into small groups. Assign a task to each group to compare a set of integer and fraction pairs, answer using =, <, or >.
Teacher provides feedback and corrects any misconceptions.
Facilitate a quick class discussion: ask learners the strategy they used to find it easy to compare fractions.
Answer any remaining questions.</td><td colspan="2">Learners respond verbally
Learners comparing integers on a number line.
Learners work on practice problems with teacher guidance.
Learners collaborate on additional practice problems in groups of 4.
1. Use >, < or = to make the statement true.
a. 79 97
b. -9 -19
c. $\frac{3}{4}$ 0.75
d. $\frac{22}{50}$ $\frac{44}{100}$
e. $\frac{1}{25}$ 0.25
Learners work in derive their own way to compare the numbers given.
Groups create a short presentation using paper to explain how they reached their answers.
Groups present their findings briefly.</td></tr>
</table>

	Peers provide constructive feedback, pointing out strengths and suggesting improvements where possible.
Consolidation: provide opportunities for learners to ask questions to seek clarifications. Learners reflect on their learning and share what they have learned,	
Classwork/Task/Homework/Exercise: N/A	
Reflection: Most learners about 95% showed that they understood the concept taught	
Compensatory teaching:	
Supervisor:	**Signature:**

<table>
<tr><td>Teacher: Mr. Kahuli Moses</td><td>Multimodal Lesson 2
Grade: 8</td><td>Duration: 40 minutes</td></tr>
<tr><td colspan="3">Subject: Mathematics</td></tr>
<tr><td colspan="3">Theme: 1. Numbers</td></tr>
<tr><td colspan="3">Topic: (g) Estimation</td></tr>
<tr><td colspan="3">Teaching Aid: chalk, chalkboard, handouts, projector</td></tr>
<tr><td colspan="3">Lesson Objective: Acquire further knowledge on comparing, ordering and estimation of integers and fractions.</td></tr>
<tr><td colspan="3">Specific Objectives: Round numbers to the nearest whole number and power of 10.
Round decimal fractions up to two decimal places.</td></tr>
<tr><td colspan="3">Lesson Presentation Content</td></tr>
<tr><td colspan="2">Teacher's Activities</td><td>Learner's Activities</td></tr>
<tr><td colspan="2">Activate prior knowledge by writing numbers on the board e.g., 325, 4.678, 1289 and ask learners to round these to the nearest whole number and the nearest ten.
The teacher introduces the concept of rounding numbers to the nearest whole number, power 10, and decimal places.
Present examples of rounding numbers on the board.
Provide several examples with guided practice such as connecting rounding to real-life estimation by providing learners with a shopping list and prices (e.g., N$4.78, N$13.95). Ask them to round prices to the nearest whole number and estimate the total cost.
Explain the rules and procedures for rounding to different place values.</td><td>Learners work on practice problems with teacher guidance.
Learners work on additional rounding problems independently.
On shopping list and prices learners use calculators to check how close their estimates were to the exact total.
Watch a short video on rounding off.
Class work: learners work in pairs and present their answers back to the class.
1. Round the followings to given degrees in brackets
a. 1836 (T)
b. 11111(H)
c. 3.229 (2dp)
d. 11.991 (1dp)
e. 9.0999 (3dp)</td></tr>
</table>

Divide learners into small groups and assign each group a set of problems (including both whole numbers and decimals). Teacher circulates the room to provide assistance as needed. Teacher provides feedback and corrects any misconceptions.	Groups explain their solutions to the class, focusing on their reasoning.
Consolidation: provide opportunities for learners to ask questions to seek clarifications rounding concepts. Learners reflect on their learning and share strategies they found helpful for rounding numbers.	
Classwork/Task/Homework/Exercise:	
Reflection: Most learners showed that they were interested and could do better.	
Compensatory teaching:	
Supervisor:	**Signature:**

<table>
<tr><td>Teacher: Mr. Kahuli Moses</td><td>Multimodal Lesson 3
Grade: 8</td><td>Duration: 40 minutes</td></tr>
<tr><td colspan="3">Subject: Mathematics</td></tr>
<tr><td colspan="3">Theme: 1. Numbers</td></tr>
<tr><td colspan="3">Topic: (g) Ordering</td></tr>
<tr><td colspan="3">Teaching Aid: chalk, chalkboard, handouts, projector</td></tr>
<tr><td colspan="3">Lesson Objective: Acquire further knowledge on comparing, ordering and estimation of integers and fractions.</td></tr>
<tr><td colspan="3">Specific Objectives: Order integers and/or fractions in ascending and descending order.</td></tr>
<tr><td colspan="3">Lesson Presentation Content</td></tr>
<tr><td colspan="2">Teacher’s Activities</td><td>Learner’s Activities</td></tr>
<tr><td colspan="2">Recall prior knowledge on integers and fractions by displaying numbers (a mix of integers and fractions) on the board. Ask learners which of these is the smallest and which is the largest.
Use a number line (drawn on the board to visually show how integers and fractions can be ordered.
Steps to order fractions: Find a common denominator for fractions. And then compare numerators to determine order.
Demonstrate examples for both ascending and descending order, ensuring a mix of integers and fractions.
Divide learners into small groups and Provide each group with number cards containing a mix of integers and fractions. Ask the learners to arrange the cards in ascending or descending order and justify their sequence.</td><td>Learners work on additional practice problems collaboratively with other peers.
Learners to arrange the cards in ascending or descending order and justify their sequence.
Present examples of ordering integers and fractions on the board with teacher’s guidance.
Learners work on real world application task that requires ordering integers and fractions.
Class work:
1. Oder the following in ascending order -14; -36; -41; 36; 42
2. Oder the following in descending order $\frac{3}{4}; \frac{3}{5}; \frac{5}{6}; \frac{7}{10}$
Derive own way on how to order integers and fractions</td></tr>
</table>

Consolidation: the teacher summarizes the key points of the lesson. Provide opportunities for learners to ask questions to seek clarifications. Learners reflect on their learning and share what they have learned	
Classwork/Task/Homework/Exercise: N/A	
Reflection: More than 95 % showed that they understood the concept well.	
Compensatory teaching:	
Supervisor:	**Signature:**

Appendix 13: Control group lesson plans

<table>
<tr><td>Teacher: Mr. Kahuli Moses</td><td>Traditional Lesson 1
Grade: 8</td><td>Duration: 40 minutes</td></tr>
<tr><td colspan="3">Subject: Mathematics</td></tr>
<tr><td colspan="3">Theme: 1. Numbers</td></tr>
<tr><td colspan="3">Topic: (g) Comparing</td></tr>
<tr><td colspan="3">Teaching Aid: chalk, chalkboard and textbook</td></tr>
<tr><td colspan="3">Lesson Objective: Acquire further knowledge on comparing, ordering and estimation of integers and fractions.</td></tr>
<tr><td colspan="3">Specific Objectives: Use =, < (strictly less than) and > (strictly greater than) to compare integers and/or fractions</td></tr>
<tr><td colspan="3">Lesson Presentation Content</td></tr>
<tr><td>Teacher's Activities</td><td colspan="2">Learner's Activities</td></tr>
<tr><td>The teacher introduces the lesson and present examples of comparing integers and fractions on the board.

Give the rules and strategies for comparing integers and fractions.

Teacher writes corrections on the board.</td><td colspan="2">Learners copy the examples
Learners work on the activity individually
2. Use >, < or = to make the statement true.
f. 79 97
g. -9 -19
h. $\frac{3}{4}$ 0.75
i. $\frac{22}{50}$ $\frac{44}{100}$
j. $\frac{1}{25}$ 0.25

Learners work on the activity by using the examples and exact strategies given by the teacher and not deriving own strategies.</td></tr>
<tr><td colspan="3">Consolidation: read through the given notes for learners to master it as it is.</td></tr>
<tr><td colspan="3">Classwork/Task/Homework/Exercise: N/A</td></tr>
<tr><td colspan="3">Reflection: 60% of learners follow what the teacher have demonstrated</td></tr>
<tr><td colspan="2">Supervisor:</td><td>Signature:</td></tr>
</table>

<table>
<tr><td>Teacher: Mr. Kahuli Moses</td><td>Traditional Lesson 2
Grade: 8</td><td>Duration: 40 minutes</td></tr>
<tr><td colspan="3">Subject: Mathematics</td></tr>
<tr><td colspan="3">Theme: 1. Numbers</td></tr>
<tr><td colspan="3">Topic: (g) Estimation</td></tr>
<tr><td colspan="3">Teaching Aid: chalk, chalkboard, textbook</td></tr>
<tr><td colspan="3">Lesson Objective: Acquire further knowledge on comparing, ordering and estimation of integers and fractions.</td></tr>
<tr><td colspan="3">Specific Objectives: Round numbers to the nearest whole number and power of 10.
Round decimal fractions up to two decimal places.</td></tr>
<tr><td colspan="3">Lesson Presentation Content</td></tr>
<tr><td colspan="2">Teacher's Activities</td><td>Learner's Activities</td></tr>
<tr><td colspan="2">The teacher introduces the concept of rounding numbers to the nearest whole number, power 10, and decimal places.
Present examples of rounding numbers on the board
Write the rules and procedures for rounding to different place values.
Teacher circulates the room to provide assistance as needed.
Teacher provides feedback and corrects any misconceptions.</td><td>Copy the notes, rules and procedures for rounding to different place values.
Learners work on additional rounding problems independently.
See some examples from the textbook.

Class work: learners work individually using the exact rules given by the teacher.
2. Round the followings to given degrees in brackets
f. 1836 (T)
g. 11111(H)
h. 3.229 (2dp)
i. 11.991 (1dp)
j. 9.0999 (3dp)</td></tr>
<tr><td colspan="3">Consolidation: Sum up by reading through the notes for learners to master it.</td></tr>
<tr><td colspan="2">Supervisor:</td><td>Signature:</td></tr>
</table>

<table>
<tr><td>Teacher: Mr. Kahuli Moses</td><td>Traditional Lesson 3
Grade: 8</td><td>Duration: 40 minutes</td></tr>
<tr><td colspan="3">Subject: Mathematics</td></tr>
<tr><td colspan="3">Theme: 1. Numbers</td></tr>
<tr><td colspan="3">Topic: (g) Ordering</td></tr>
<tr><td colspan="3">Teaching Aid: chalk, chalkboard, handouts, projector</td></tr>
<tr><td colspan="3">Lesson Objective: Acquire further knowledge on comparing, ordering and estimation of integers and fractions.</td></tr>
<tr><td colspan="3">Specific Objectives: Order integers and/or fractions in ascending and descending order.</td></tr>
<tr><td colspan="3">Lesson Presentation Content</td></tr>
<tr><td colspan="2">Teacher’s Activities</td><td>Learner’s Activities</td></tr>
<tr><td colspan="2">The teacher introduces the concept of ordering integers and fractions in ascending and descending order.
Write the steps and strategies for ordering integers and fractions.
Teacher writes feedback on the chalkboard.
to</td><td>Copy notes from the chalkboard.
Work activities individually by using exact procedures given by the teacher.

Class work:
3. Oder the following in ascending order -14; -36; -41; 36; 42
4. Oder the following in descending order $\frac{3}{4}; \frac{3}{5}; \frac{5}{6}; \frac{7}{10}$</td></tr>
<tr><td colspan="3">Consolidation: the teacher sums up by reading out the key concepts to the learners to master it.</td></tr>
<tr><td colspan="3">Classwork/Task/Homework/Exercise: N/A</td></tr>
<tr><td colspan="3">Reflection: Some learners understand (about half of the class)</td></tr>
<tr><td colspan="3">Compensatory teaching:</td></tr>
<tr><td colspan="2">Supervisor:</td><td>Signature:</td></tr>
</table>

Appendix 14: Permission letter from ED

REPUBLIC OF NAMIBIA

MINISTRY OF EDUCATION, ARTS AND CULTURE

Enquiries: Mr. J. Bantam
Tel: +264 61 -293 3202
Fax: +264 61- 293 3922
Email: johannesbantam@gmail.com
File no: 13/2/9/1

Luther Street, Govt. Office Park
Private Bag 13186
Windhoek
Namibia

Moses Kahuli
P. O. Box: 848
Rundu
Email:carhuly@gmail.com

Dear Mr Kahuli,

SUBJECT: PERMISSION TO CONDUCT RESEARCH IN THE KAVANGO WEST REGION

The Ministry wishes to acknowledge receipt of your letter dated 08 July 2024 seeking for permission to conduct academic research for your Doctor of Philosophy in Education. The research which is titled:' *Effects of a Multi-modal Approach in Developing Number Sense in Grade 8 learners in Ncamagoro Circuit, in the Kavango West Region*".

Permission has been granted to you. However, you have to seek for further approval from the Regional Director of Education, Arts and Culture of the Kavango West region, as per the Basic Education Act (3 of 2023), Section 37, to ensure that the following conditions are met:

- Participation is voluntary,
- Permission is sought from the principals of the schools,
- Minimum interruption during school lessons, as well as learners studying time,
- Staff members' normal work is not disrupted during your interviews.
- Parental consent should be granted by the parents / guardians of all participants below the age of 16 years.

Furthermore, you are kindly requested to share your research findings with the Ministry after completion of the research project. You may contact Mr N. Eiman on the above provided contacts at the Directorate: Programmes and Quality Assurance (PQA) for submission of your research findings at the above indicated details.

We wish you the best in conducting your research and workshops and the Ministry looks forward to hearing from you upon completion of your studies.

Yours sincerely,

08/08/2024

Sanet L. Steenkamp
EXECUTIVE DIRECTOR

All official correspondence must be addressed to the Executive Director

Appendix 15: Permission letter from IOE

KAVANGO WEST REGIONAL COUNCIL
DIRECTORATE EDUCATION, ARTS AND CULTURE

Tel No: (066) 264976
Email: kavangowesteac@yahoo.com

Private Bag 6193, Nkurenkuru
Namibia

Enquiries	:	Ms. A.M. Likuwa	Telephone No.	:	26466-255774
Cell	:	0814020400/0814779812	Fax No	:	N/A
E:mail	:	amlikuwa94@gmail.com	Date	:	09/08/2024

Ref no: 26/1/16

Mr. Moses Kahuli
P.O.Box 848
Rundu

Dear Mr. Kahuli

SUBJECT: PERMISSION TO CONDUCT RESEARCH AT SCHOOLS IN KAVANGO WEST REGION:

1. Above mentioned subject, bears reference.
2. We are hereby acknowledge that we have received your request letter dated 02 August 2024, seeking for permission to conduct an academic research on the topic: **Effects of a multi-modal approach in developing number sense in grade 8 learners in Ncamagoro Circuit**, Kavango West.
3. Taking this into consideration the Inspector of Education has no objection to approve this request, permission is granted as per your request on the following conditions:
   - Permission is sought from the school Principals.
   - Teaching and learning is not interrupted.
   - Participation is voluntary.
4. Your cooperation in this regard is highly appreciated and we wish you all the best in conducting your research.

Yours in Education,

Mr. V. N. Kamukwanyama
Inspector of Education
Ncamagoro Circuit

KAVANGO WEST REGIONAL C... OFFICE OF THE INSPECTOR NC... 09 AUG 2024 PRIVATE BAG 619... DIRECTORATE...

KAVANGO WEST REGIONAL COUNCIL OFFICE OF THE INSPECTOR NCAMAGORO CIRCUIT Date 09 AUG 2024 PRIVATE BAG 6193 NKURENKURU DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Appendix 16: Permission letter from RD

KAVANGO WEST REGIONAL COUNCIL
DIRECTORATE EDUCATION, ARTS AND CULTURE

Tel No: (066) 274 2000
Email: kavangowesteac@yahoo.com
Enquiries: Leena N. Muhoka
Ref: 26 / 1 / 16

Private Bag 6193, Nkurenkuru
Namibia

26 July 2024

Mr. Moses Kahuli
P.O.Box 848
Rundu

Dear Mr. Kahuli

SUBJECT: PERMISSION TO CONDUCT RESEARCH AT SCHOOLS IN KAVANGO WEST REGION

1. The Directorate of Education, Arts and Culture Kavango West wishes to acknowledge receipt of your letter dated 25 July 2024, seeking for permission to conduct an academic research on the topic: **Effects of a multi-modal approach in developing number sense in grade 8 leaners in Ncamagoro Circuit,** Kavango West.

2. Permission is hereby granted, provided you seek for further clearance from the Circuit Inspector of Education where you wish to conduct your research to ensure that:

    - Permission is sought from the School Principals
    - Teaching and Learning is not interrupted
    - Participation is voluntary

3. Furthermore, you are kindly requested to share your research findings with the Directorate of Education, Arts and Culture, Kavango West after completion of your study. You may contact the Deputy Director for Programme and Quality Assurance (PQA) for submission of a summary of your research findings.

4. We wish you all the best in conducting your research.

Yours Sincerely,

PONTIANUS V. MUSORE
DIRECTOR OF EDUCATION, ARTS AND CULTURE
KAVANGO WEST

26.07.2024
DATE

CC: Inspector of Education: Ncamagoro Circuit

All official correspondences must be addressed to the office of the Chief Regional Officer

Appendix 17: Pre-test, post-test and follow up assessment scores for both Control group (given code C) and experimental group (given code E)

Statisty

Clear Table Export / Import Settings

nominal	metrisch	metrisch	metrisch	nominal	metrisch	metrisch	metrisch
Control Group Lea	Control group Pre-	Control Group Pos	Control Group Foll	Experimental Grou	Experimental Grou	Experimental Grou	Experimental Grou
C1	10	11	6	E1	8	17	13
C2	9	12	8	E2	11	18	12
C3	14	13	9	E3	15	20	18
C4	10	9	17	E4	11	18	24
C5	16	17	20	E5	15	19	16
C6	19	20	17	E6	10	16	15
C7	15	18	19	E7	12	23	18
C8	18	17	9	E8	16	24	17
C9	14	12	23	E9	9	20	22
C10	9	13	18	E10	13	20	24
C11	12	14	18	E11	8	19	20
C12	10	8	17	E12	11	18	19
C13	11	12	21	E13	16	19	14
C14	7	8	17	E14	14	18	13
C15	5	9	18	E15	10	14	15
C16	15	21	11	E16	9	17	17
C17	12	18	13	E17	10	14	16
C18	8	7	9	E18	16	14	19
C19	11	19	14	E19	12	19	20
C2	12	20	17	E20	10	21	21
C21	13	21	16	E21	14	16	19
C22	18	26	12	E22	12	20	18
C23	20	19	12	E23	14	14	12
C24	11	13	11	E24	13	14	14
C25	14	19	14	E25	16	17	17
C26	11	12	11	E26	15	20	18
C27	11	14	11	E27	13	14	12
C28	13	15	13	E28	16	15	13
C29	14	16	11	E29	16	22	14
C30	15	17	11	E30	9	18	16

Appendix 18: additional box and whisker plot graphs showing the comparison between an experimental group and a control group.

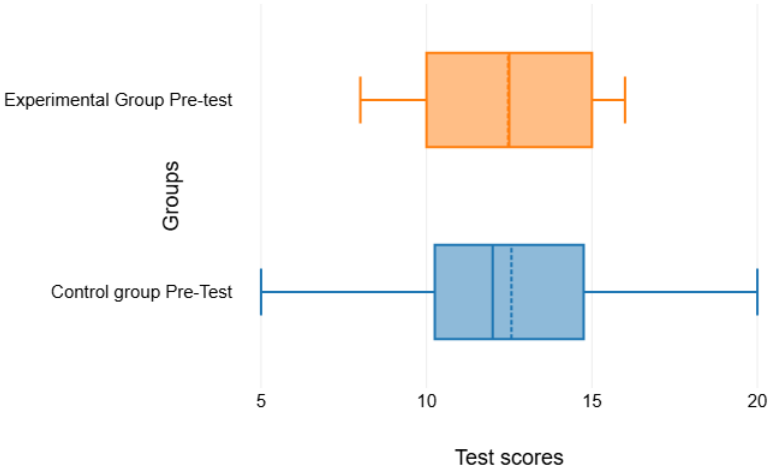


Figure 2: Above shows pre-test for both the control and experimental group.

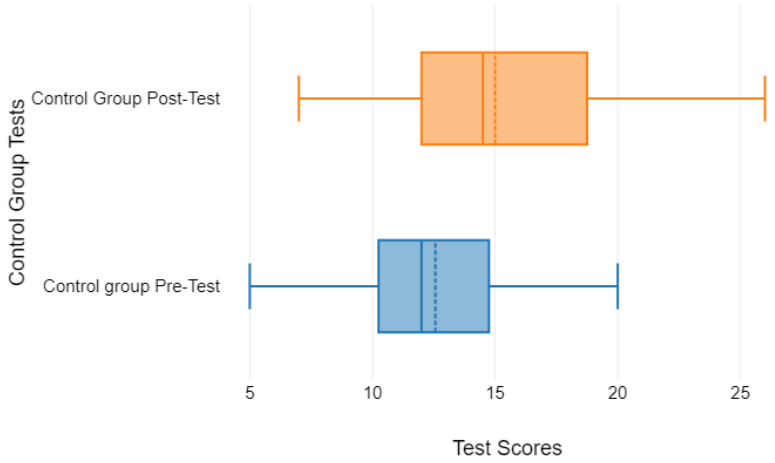


Figure 3: Above shows Paired t-test summary for pre-test and post-test for the experimental group.

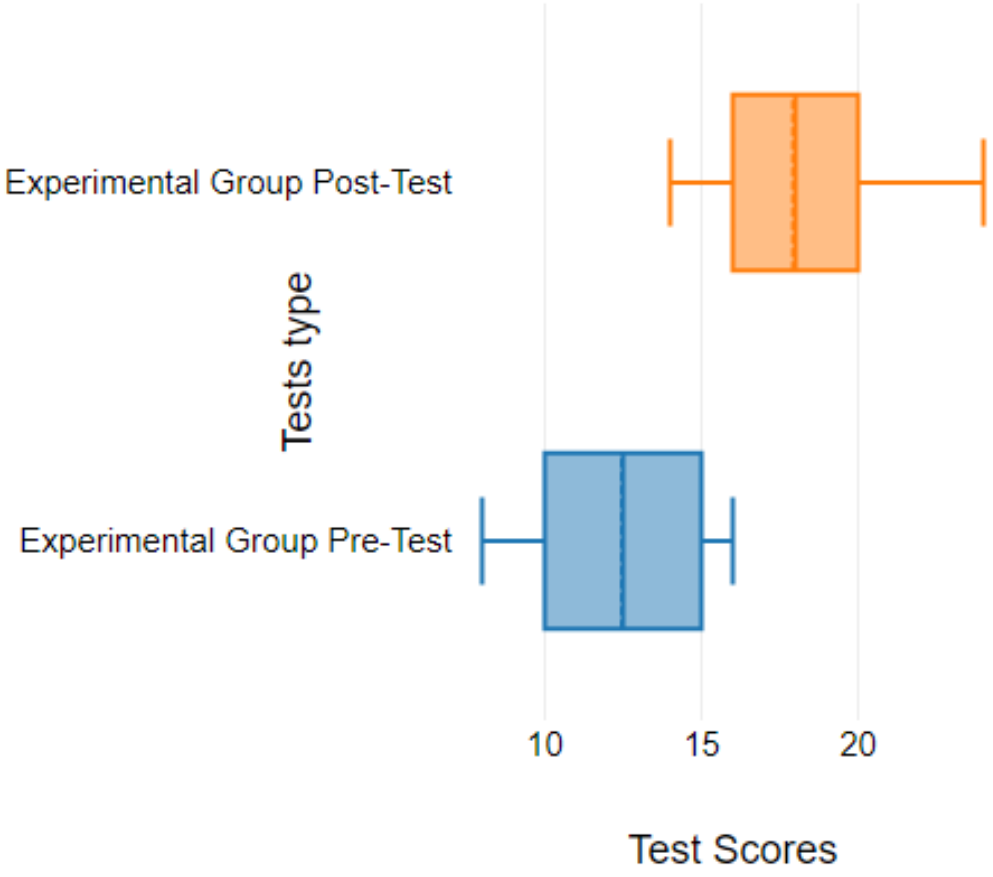


Figure 4: Above shows a paired t-test summary for pre-test and post-test for the control group.

Figure 5: Above shows the independent t-test summary of post-test comparison of control group and experimental group.

Figure 6: Above shows the independent t-test summary of follow-up assessment comparison for control group and experimental group.

Appendix 19: Editing research certificate

Thesis Editor and Proof Reader

Gabriel R Rumayi

P.O.BOX 6122, Nkurenkuru

Cell: +26481 2168815

gabsruma@gmail.com

14 March 2025

To Whom It May Concern

Re: Thesis Editing for Moses Kahuli, Student number: 201311852

I, Gabriel R Rumayi hereby confirm that I have edited and proofread the thesis for the above-mentioned student under the title, **"EFFECTS OF A MULTI-MODAL APPROACH IN DEVELOPING NUMBER SENSE IN GRADE 8 LEARNERS IN NCAMAGORO CIRCUIT, KAVANGO WEST REGION."**

Attention was given to grammar, formatting and standard academic language, maintaining the meaning and context set by the researcher. Also, the editor looked at figures and tables, reference list and gave the necessary inputs.

I believe the thesis is of value, educative and clear in its objectives.

Yours truly

.....

Gabriel R Rumayi

Language Editor

MR GABRIEL R.R
11 MAR 25
EDUCATION IS POWER
081 216 8815